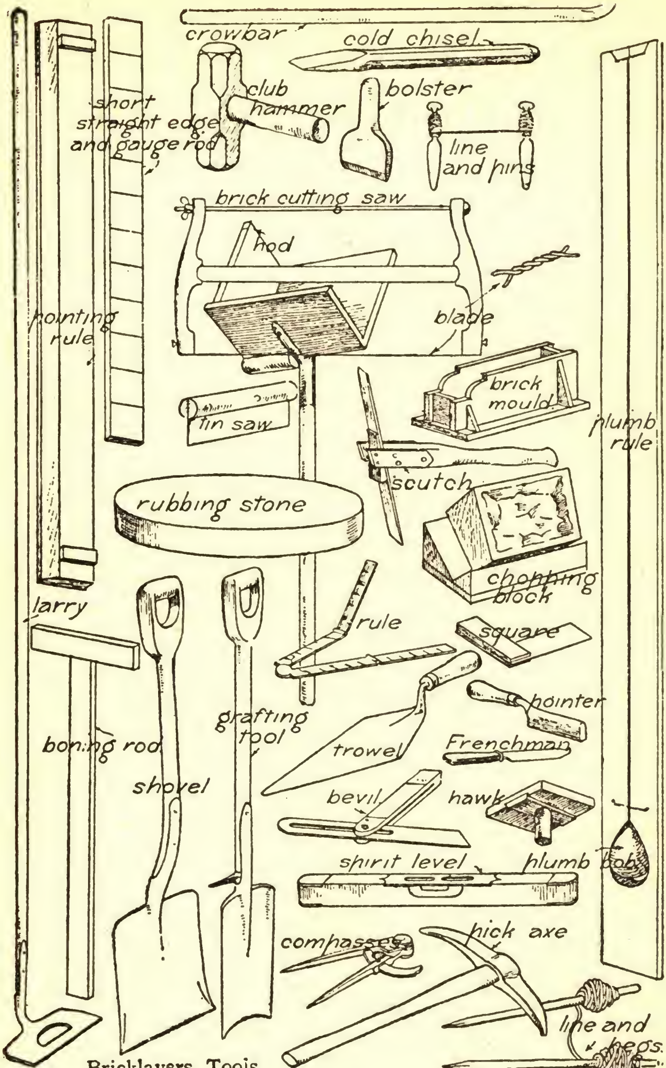
20TH CENTURY BRICKLAYER'S AND MASONS ASSISTANT

FRED T. HODGSON.



Bricklayers Tools

FRONTISPIECE

The 20th Century Bricklayer's and Mason's Assistant

PART ONE

The Bricklayer's Guide and Assistant

BEING A SERIES OF EXHAUSTIVE INSTRUCTIONS IN ALL KINDS OF BRICKLAYER'S WORK, INCLUDING LAYING FOUNDATIONS, BONDING, ARCHING, GAUGED WORK, CONSTRUCTION OF DAMP COURSES, COPING, BUILDING BRIDGES, PIERS, CHIMNEYS, FLUES, FIRE-PLACES, CORBELING, PLAIN AND FANCY CORNICES, BRICK PANELING, PILASTERS, PLINTHS, AND OTHER BRICKWORK, PLAIN AND ORNAMENTAL

PART TWO

The Stone Mason's Assistant

BEING A SERIES OF PRACTICAL INSTRUCTIONS FOR THE USE OF STONE MASONS, STONE CUTTERS, MARBLE WORKERS AND STONE CONTRACTORS; SHOWING HOW TO LAY OUT AND WORK ALL KINDS OF ARCHES, STONE STEPS, STAIRS AND HAND-RAILS, SKEW BRIDGES AND ARCHES, CIRCLE ON CIRCLE WORK, NICHES, CLASSIC AND GOTHIC STONEWORK, PIERS AND OTHER STONEWORK, PLAIN AND ORNAMENTAL

BY

FRED T. HODGSON,

Author of "Modern Carpentry," "Practical Uses of the Steel Square," "Modern Estimator," Etc., Etc.

Illustrated

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CHICAGO

1905

THIS BOOK

IS DEDICATED WITH GREAT LOVE

TO MY INFANT GRANDSON,

FREDERICK ORRIN HODGSON;

WHOSE FUTURE CAREER IT

IS HOPED, MAY BE

USEFUL, ADVANTAGEOUS, AND BENEFICENT

TO ALL MANKIND.

Sic itur ad astra.

PREFACE

While the mason, the worker in cut stone, is generally supposed to be a more skillful and a more artistic workman and as a rule takes precedence over the man who works in brick alone, I have in this work dared to reverse this order and devote the first part of this volume to enhance the interest of the worker in the more humble but certainly more useful material—brick.

When bricks were first employed as building material matters but little to the practical workman, but that bricks were employed before history was written may be accepted as a fact, for we have evidence of it in many parts of the world; and whether brick or stone was first used in the construction of habitations for man need not trouble us at this late date.

What we moderns want to know is, "how to make better bricks than were ever before made and how to handle them so as to make solid, artistic and economical brickwork"; and to this end this volume, or rather this first part of the volume, is devoted—not, I hope, without some success. Of course, in a volume of this kind, which is intended altogether to show in the clearest possible manner the various methods employed in the trade, it is quite natural that I should, in a great measure, follow in the footsteps of other writers, and I may say right here that besides adding some matter drawn from my own experience, I have taken much of the material used from some of the very best authorities who have written on the subject,

among whom may be mentioned Gwilt, Nicholson, Ferguson, Weale, Encyclopedia Britannica, Parker, Scott, Burn, Trautwine, Mitchell, Richards, Ward Lock & Co.'s works, Lynch, Hammond, Sheldon, Powell, Rivington's Construction, Baker, Kidder, Knight's Mechanical Dictionary, Magginis, and many other noted writers on bricks and brickwork. The various magazines devoted to architecture and building have also furnished me with many of the items, ideas and illustrations that will be found in the work, and I name some of the most prominent of the journals from which I have made copious extracts: "American Architect," "Canadian Architect," "Architects and Builders' Magazine," "Inland Architect," "National Builder," "Carpentry and Building," "Building World," "Illustrated Carpenter and Builder," "The Builder," "The Building News," "The Architect," besides selections from many other sources.

BRICKLAYERS' GUIDE

PART I

FOR THE BRICKLAYER

SOME DEFINITIONS

Throughout this work the terms "plan," "elevation" and "section" will be constantly used, and for the benefit of those who do not understand these terms the following definitions are intended:

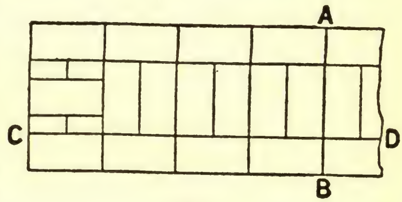


Fig. 1.

Plan.—A plan is a drawing representing any object as it would appear when looking down upon it. Thus, in drawing the plan of an 18-in. wall, not including the footings, draw the outside face lines and joints as in Fig. 1.

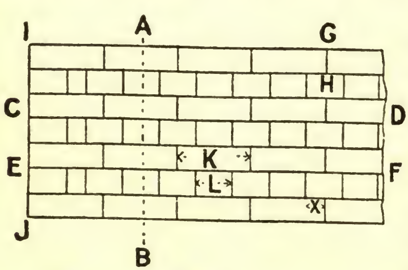


Fig. 2.

Elevation.—An elevation is the view of any object when looking directly at it. It may be vertical, or at any inclination to the horizontal plane. Elevations are known as front, back, and side; hence, again illustrating by means of the 18-in. wall, the front and back elevations would be shown as in Fig. 2.

Section.—A section is the view of an object representing it as it would appear when cut horizontally or vertically by a plane parallel or at any angle to the face or end. For instance, a vertical section, A B, through Fig. 2 would appear as Fig. 3.

Course.—A course is the name given to one row of bricks, in any thickness of wall, between two bed joints, as C D, Fig. 2.

Bed Joints.—These are the mortar joints between the courses, as E F, Fig. 2.

Cross Joints.—The short vertical joints at right angles to and connecting the bed joints are known as cross joints or perpends (see G H, Fig. 2).

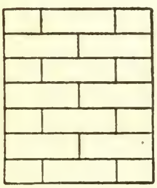


Fig. 3.

Transverse Joints.—When the cross joints are continued through the thickness of the wall they are called transverse joints, as A B, Fig. 1.

Wall Joints.—These are the joints in the thickness of and parallel to the face of the wall C D, Fig. 1.

Quoins.—The external angles of a wall are called quoins (see I J, Fig. 2).

Stretcher.—This is the 9-in. face of a brick, K, Fig. 2.

Header.—The 4½-in. end of a brick, L (see Fig. 2).

Bats.—The half of a brick is known as a 4½-in. bat, while any length above this and below 9 in. is known as a three-quarter bat.

Lap.—The horizontal distance between the cross joints in two successive courses is called the lap. This should never be less than one-quarter of the length of the stretcher, X, Fig. 2.

Closers (Kings and Queens).—A king closer is a brick

made to appear as a header on one end and a closer on the other (Fig. 4).

A queen closer is a brick cut, if possible, 9 in. in length by 2¼ in. on the face; most usually the 9 in. are made up of two 4½-in. lengths (Fig. 1).

Besides these, there are other closers that will be described later on.

The average length of a brick is 8¾ in., but with the addition of either a cross joint or a wall joint it is reckoned as 9 in.

The width is 4¼ in., and for the same reason as given above it is considered to be 4½ in.

The average thickness is 2¾ in, and four courses with the bed joints will measure 11½ in., 12 in., or 12½ in., etc., according to the thickness of the joints.

The usual practice is to build the work four courses to a foot.

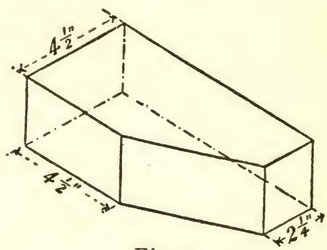


Fig. 4.

A wall 1½ bricks thick is usually called a 14-in. wall, 2½ bricks thick a 23-in. wall, whereas walls 2 bricks and 3 bricks thick are known as 18-in. and 27-in. walls, respectively.

FOUNDATIONS

The first thing to be considered in any brick structure is the foundation, and it is but proper we should devote some space at the outset to this important part of the subject. First we have, the necessity for foundations. Walls of buildings resting on ground of variable strength often fracture, due to the unequal

settlement of the work. To prevent failure in this manner the base of the walls of the building may be extended and supported by suitable foundations.

The object of foundations is to prevent inequality of settlement and distribute the weight of the structure equally over the substratum.

The bases of structures are invariably made wider than the superincumbent mass, to increase the stability and to counteract all the following damaging forces that tend to cause failure.

Damaging Forces.—The principal causes of failure are those which induce settlement, such as inequalities of earth resistance; the compressibility of mortar joints; lateral escape of soft soil, sliding of the substratum on sloping ground; the withdrawal of water; distributed lateral pressures, causing overturn, such as wind pressure, and thrust of barrel vaulting or of an untied couple raftered roof; concentrated lateral pressure which induces settlement and overturn, such as the thrust of framed floors, trussed roofs and groined vaults subjecting small areas of support to great pressures.

Inequality of Settlement.—Inequality of settlement in buildings takes place from two causes: (1) the compressibility of the mortar joints, (2) the compressibility of the soil.

An allowance of 1 in. in 24 ft. of brickwork in lime mortar is often provided for settlement, as in the example of the extremities of bridging joists of floors, at one end being supported by a brick wall and the other extremities by iron columns, etc.

Nearly all soils, with the exception of solid rock and gravel, are compressible under pressures often attained in buildings. It is therefore impossible, where large

buildings are erected on other soils, to avoid settlement; and the fact of any building settling is of no great import, provided the settlement be uniform and of no great depth, and the relative position of the parts of the structure unaltered. But where the resistance of the soil of every part of the site is not uniform, there is a risk of the above defect occurring, and special precautions must be taken to distribute the pressure to suit the varying strengths of the substratum.

Lateral Escape.—Heavy structures erected upon soft soils, such as running sands and peat, squeeze out from beneath the foundation, unless means are taken to confine the soil to the required area; this is usually accomplished by sheet piling, as described later.

Sliding.—This is a defect usually occurring where the building is erected on the slope of a hill, and the strata inclined, being depressed in the direction and towards the bottom of the slope. The weight of the building is liable to cause the strata to become detached and slide. This is prevented in two ways: (1) by driving piles at intervals to a considerable depth, thus connecting the strata; this method is often objectionable, tending, as it does, to shake and disturb the soil; (2) by building a retaining wall; this is the better method, as it not only supports, but also protects the strata from the effects of the atmosphere, which in soils easily affected by the latter is a desideratum.

Withdrawal of Water from Foundation Earth.—Edifices built on damp soil, such as a sand overlying a clay, have their stability endangered should the water be drained away after the building has been erected, as it will cause the foundation earth to occupy a less volume and in the sinking will tend to fracture or

overturn the walls; therefore the depth of the concrete foundation must be arranged below any probably adjacent cutting.

Distributed Overturning Pressures.—Distributed forces acting upon the upper level of walls, such as the continuous pressure of barrel vaulting and the spreading tendencies of untied couple raftered roofs, and also the distributed pressures on wall faces, such as wind pressure, tend to cause failure in two ways: (1) by overturning, the minimum resistance being generally at the change of section, usually at the ground level; (2) by subjecting the leeward edge of the wall to the pressure sufficient to crush the material or by throwing the weight on a small area of the substratum, forcing it from its original position and causing a settlement.

The stability of walls when subjected to such distributed overturning pressures is treated in the chapter on that subject.

Concentrated Lateral Pressure.—The thrust caused by united principals, as groined faults or other forces acting at a point or along vertical lines on the wall, are often resisted by buttresses.

Atmospheric Action.—Many otherwise thoroughly reliable soils are practically reduced to the condition of mud if exposed to the effects of the atmosphere or to rain water. The variation in temperature at the different seasons also causes the ground to expand and contract considerably.

Where foundations are constructed in such soils, they must be taken sufficiently deep to be beyond the effects of the atmosphere, that is, below the line of saturation. Four feet below the ground level is usually sufficient for this purpose, the soil below this not being

affected to any appreciable extent by the percolation and subsequent freezing of rain water.

The line of saturation in the section of any part of the earth's crust represents the depth to which the soil at that part is saturated by the absorption of rain water and affected by atmospheric changes.

Excavations.—Before commencing any constructional work in connection with a building it is necessary as the first operation to carefully take the levels of the site, in order first to arrive at an estimate of the amount of earthwork to be done; and secondly, to determine the design of the basement story, this latter often being materially affected if the differences in level of the various parts of the site are great. The next operation is to level the ground. This in most instances consists in excavating and removing parts of the site, and in depositing earth in other parts to form embankments or to fill up hollow places. In order to conduct these operations in the most economical manner the levels must in all instances be taken and plotted with the greatest accuracy. This can only be efficiently done on areas of any magnitude by means of the surveyor's level, the method of employing which will be described later. All leveling operations for ordinary constructional work may be carried out by referring them to the principles laid down for performing the three following operations:

1. Taking levels of site.

2. Leveling the bottoms of trenches for drains or foundations.

3. Embanking for roads or leveling of depressions.

Instruments.—The instruments required to determine the levels of the site are: first, the surveyor's level;

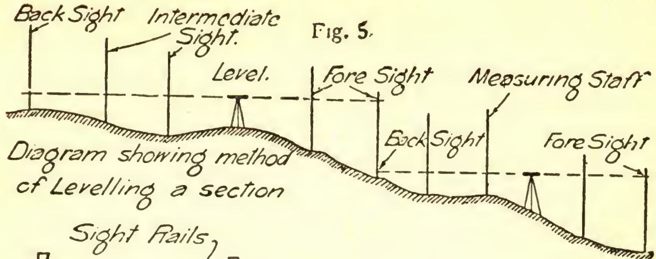
second, the measuring staff; third, ranging poles and chain or tape.

Methods of Leveling.—Taking the levels of a site may be carried out in one of three ways: First, by taking a number of section lines across the site; secondly, by erecting the level in a commanding position and taking the relative heights of the salient points and noting them on plan (this method is only applicable for small sites); thirdly, by contours.

In all three methods it is necessary to have a datum level to commence from, and from which all other levels can be referred. A line on some permanent structure in the immediate vicinity is usually taken, or if such does not exist, a stout stake is driven in the ground in a position away from the work where it is not likely to be disturbed.

First Method.—A number of sections are ranged across the site, each line being numbered or lettered; the level is then set up on or in close proximity to the first line and the datum; the measuring staff is then held by an assistant on the datum point and then on the extremity of the line, the relative heights of the two points being recorded in a field book kept for that purpose. A number of points on the line are then taken, and the measuring staff is held over them and their relative heights are recorded, and their distances from the beginning of the line are measured. When the bottom of the measuring staff rises above or the top becomes depressed below the line of sight through the rise or depression of the ground, the level must be moved further along the line and the preceding operations repeated. Fig. 5 illustrates the method. The following is a form of field book with the reading for a section entered:

Fig. 5.



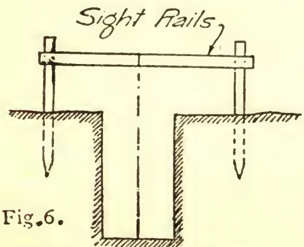


Fig. 6.

Sight Rail with Posts fixed in ground

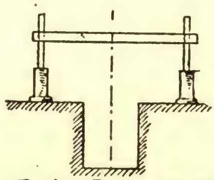


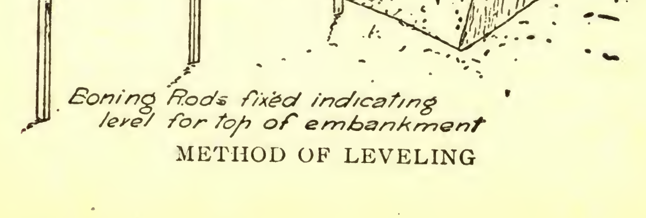
Fig. 7.

Sight Rail with Posts fixed in drain pipes

Fig. 8.

Boning bottom of Trench from Sight Rails

Fig 9.



Boning Rods fixed indicating level for top of embankment

METHOD OF LEVELING

FIELD LEVEL BOOK

Back Sight.	Inter. Sight.	Fore-Sight.	Rise.	Fall.	Reduced Levels.	Distance.	Total Distance.	Remarks.
						chains		
4.15	......	......	......	....	100'.0	.....	......	Bench Mark A
	4.13	......	.02	....	100.02	1	......	1 peg
	5.01	......	......	.88	99.14	2	......	2
	4.86	......	.15	....	99.29	3	......	3
	6.06	......	......	1.20	98.09	4	......	4
		8.02	......	1.96	96.13	5	......	5
12.25								
	8.46	......	3.79	....	99.92	6	......	6
	3.04	......	5.42	....	105.34	7	......	7
		2.15	.89	....	106.23	7.57	......	Bench Mark B
12.60								
	7.19	......	5.41	....	111.64	8.57	......	8
		2.53	4.66	....	116.30	9.57	......	9
9.37								
	5.75	......	3.62	....	119.92	10.57	......	10
		3.94	1.81	....	121.73	11.57	11.57	Bench Mark C
			25.77	4.04	21.73			
			4.04					
			21.73					

The above shows a typical field book. The reduced level of the first point is taken as 100 ft. above a datum level; the levels are all read in feet and hundredths of a foot; the distances are taken in chains and links, but may be taken in feet and inches. The rise and fall columns should be balanced, also the first and last reading in the reduced levels; these two quantities will equal each other if the computations have been correctly made.

Second Method.—The second method is evident from the previous explanations.

Third Method.—The method of contouring is the most useful, but takes the longest time to perform it:

it consists in describing upon a plan a series of level lines with a uniform vertical interval between them. To carry out this operation it is usual to erect the instrument on the highest point of any section of the area to be contoured, and from this point to range a number of lines radiating from it, their direction being fixed by taking their bearings. The height of the instrument is then taken, and the man with the measuring staff is directed up or down each line in succession until a number of points of the required vertical interval and their distances from the initial point are determined. This method is most useful for laying out large estates where extensive works are projected, as on such a plan the problems of drainage and roads of convenient and economical gradients can easily be laid down.

When the levels of a site are known, and the building is planned, and the position of one of its leading lines is determined, to set out the remaining lines of an ordinary building becomes a simple matter, only requiring great care in the measurements of the parts. If the setting out is rendered difficult through differences of level in the paths, a theodolite would very much simplify the operations.

Boning Method of Leveling.—This operation is used for the leveling of trenches, ground work, paving, etc. There are three rods in a set; two of these are leveled at a distance of about 10 ft. apart; a third rod is then leveled at a similar distance, taking care to reverse the long level. The center rod is then removed, and the level transmitted to any point along the line by sighting or boning over the first and third rods.

Fig. 10 shows the method of using boning rods and setting a curbstone.

Trenching.—When the lines of the building have been laid down and all its salient angles pegged out, the work of excavating the trenches commences. It is absolutely necessary that the trenches should be level along their bottoms. To ensure this, two or more sight rails (as shown in Figs. 6 and 7) are erected over the trench; it is necessary that the side posts of these should be fixed in such a position that they shall not be disturbed by any of the subsequent operations.

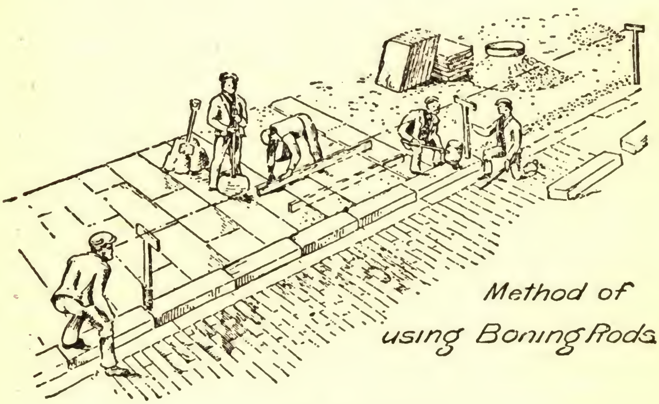


Fig. 10.

A level line is sighted through the level and marked on the sight rails; the cross bar is then fixed on each, and a mark is made on the bars plumb over the center of the trench. The width of the trench is marked out with the line and pins (see Fig. 9), and the excavation is carried on, timbering being inserted as the earth is removed, if required, by one of the methods afterwards described. When the full depth of the trench has been nearly reached, a number of points

are sunk to the exact depth by means of boning rods, the top of which is sighted between two of the sight rails, as shown in Fig. 8. The remaining parts of the trench bottom are then taken out level between the points so determined. A similar process is pursued for sinking a trench for a drain, the variation being that the sight rails have a difference in height necessary to give the required fall.

Embanking.—The method of forming an embankment is as follows: The center line of the proposed work is ranged out on the ground, and at equal intervals along the line boning rods are erected, the two extreme rods being first fixed either level or with a difference in height sufficient to give the required gradient; a rod is then erected on each of the intervals determined upon, and boned between the two extreme rods. The embankment is then commenced from one end, the earth being tipped in from carts or wagons until the tops of the boning rods are reached; sufficient earth in excess must be allowed for to compensate for compression and settlement. The width of the embankment is completed as the work is pushed forward, as shown in Fig. 9.

Timbering for Excavations.—It becomes necessary, where earth has to be excavated to any considerable depth, for foundations or other purposes, to support the sides of the cutting until the sinkings or trenches are filled in, or other action taken to permanently support the sides. This end is attained by means of timber shores, the arrangement of which is modified and governed by several conditions, such as the nature of the soil, the size of the cutting, and the special peculiarities of the particular piece of work under consideration.

There are three typical methods of strutting used for supporting the sides of narrow trenches excavated

Fig. 11.

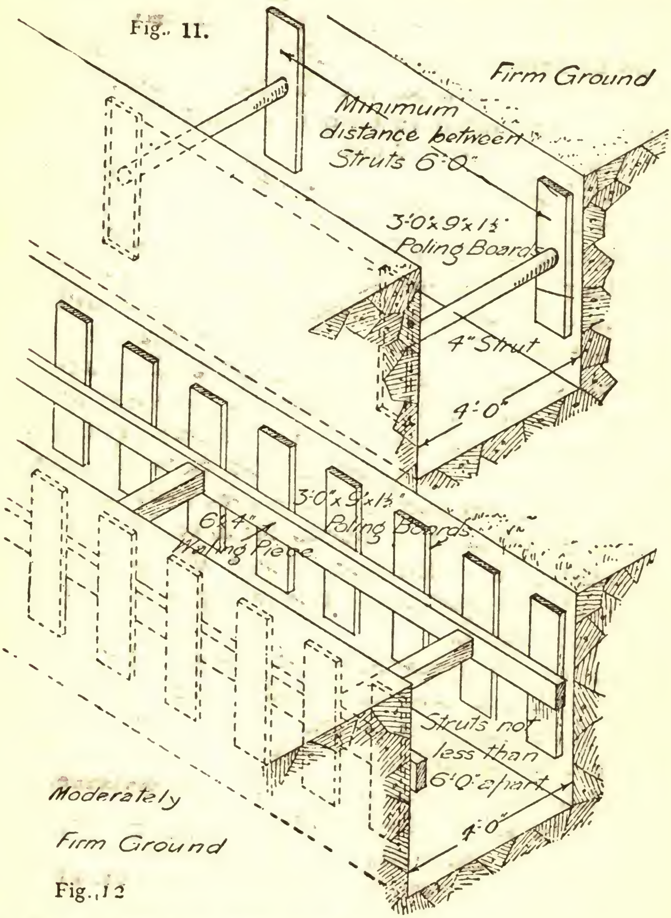


Fig. 12

for foundations or drainage work, shown in Figs. 11 and 12.

The first, used for firm ground, consists of short upright members, termed poling boards, out of $9 \times 1\frac{1}{2}$ in., usually from 3 to 8 ft. long, placed in position in pairs, one board on each side of the cutting; these are kept apart by struts out of about 4×4 in., or short ends of scaffold poles cut and driven tightly between the poling boards. The strutting is fixed as soon as the trench has been made sufficiently deep. The horizontal distance apart between the adjacent system of strutting varies according to the cohesive strength of the soil, but never less than 6 ft., which is just sufficient to allow a man to work in with effect.

The method shown in Fig. 12 is adopted where the earth requires to be supported at shorter intervals than 6 ft., and consists of upright poling boards and struts as before, but with the addition of a horizontal timber termed a waling piece. The process of fixing is as follows: The cutting is made, commencing at one end, and as soon as sufficient earth has been excavated a pair of poling boards and struts is inserted as in the first method; this process is repeated, fresh poling boards being fixed at distances apart varying with the nature of the earth, these distances being in some instances very short.

Horizontal members, 4×4 in. or upwards, are placed one on each side of cutting and strutted tightly against the poling boards. After about 12 ft. has been thus cleared, the struts which were fixed first are then knocked out; a fresh depth is commenced, and treated in a similar way.

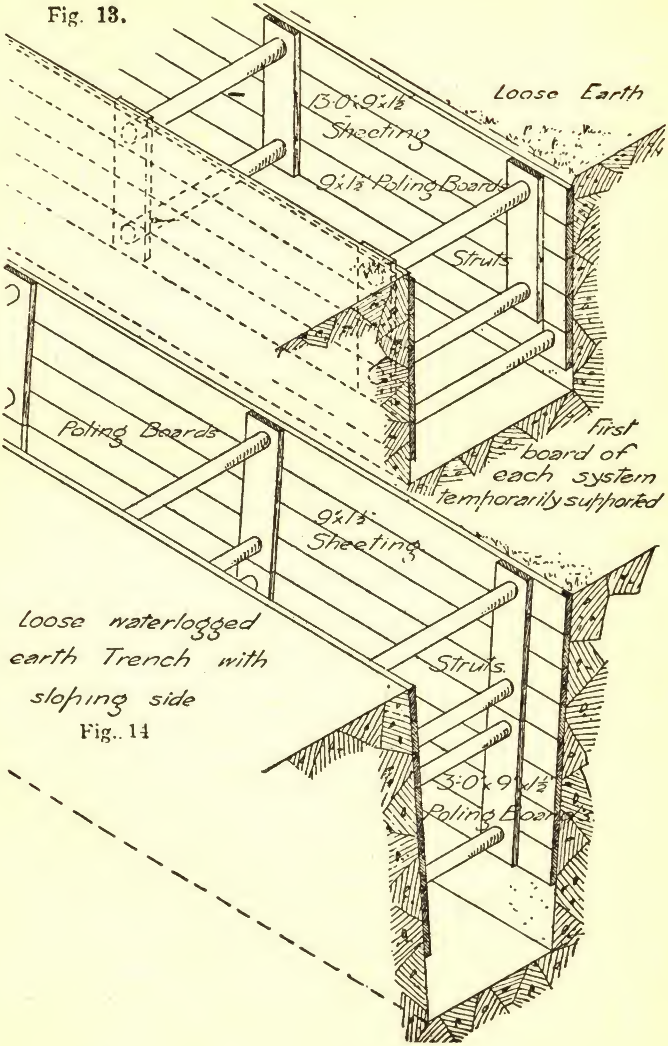
The third method is employed where the earth is very soft, and consists in laying horizontally boards, usually $9 \times 1\frac{1}{2}$ in., against the sides of the excavation; the boarding laid in this manner is termed sheeting,

which is supported by upright poling boards and struts, as shown in Fig. 13. The method of fixing is as follows: The earth is taken out to a depth of 9 in., and a pair of boards is inserted and strutted apart; another depth of 9 in. is then taken out, and sheeting fixed as before. This process is repeated until a sufficient number of boards has been inserted, usually four; upright poling boards are then placed in position against the sheeting and strutted apart, as shown in Figs. 9 and 10; the first fixed struts are now struck and cleared away.

The above system may be improved upon, when the depth of the cutting is not too great, by cutting the sides of the excavation to a slight batter, as shown in Fig. 14; by so doing the timbers are prevented from falling should the earth contract on becoming drained; it also facilitates the fixing of the struts.

Large Cuttings.—Continuous trenches, if made in bad ground, are generally arranged as shown in Fig. 15. At intervals guide piles are driven in, to which walings are bolted, and sheeting consisting of boards about 10 ft. long, shod with iron, termed runners, inserted between; these are driven a short distance into the ground, the earth between the two systems of piles being then taken out, and care taken not to excavate within a foot of the bottom end of the runners, which are again driven in and the process repeated. After the excavation of the first part, wales, consisting of whole timbers, are placed in position and strutted apart, the struts being also of balk timber. Long struts are supported in the direction of their length by short uprights secured to them by dogs. Uprights are also placed between the waling pieces as each fresh one is inserted.

Fig. 13.



loose waterlogged earth Trench with sloping side

Fig.. 14

After the ground has been excavated to the depth of the runners, a fresh system of piles and runners is driven slightly to advance of the former system, and the ground excavated as before. Cuttings are made in firm ground by excavating the earth and using ordi-

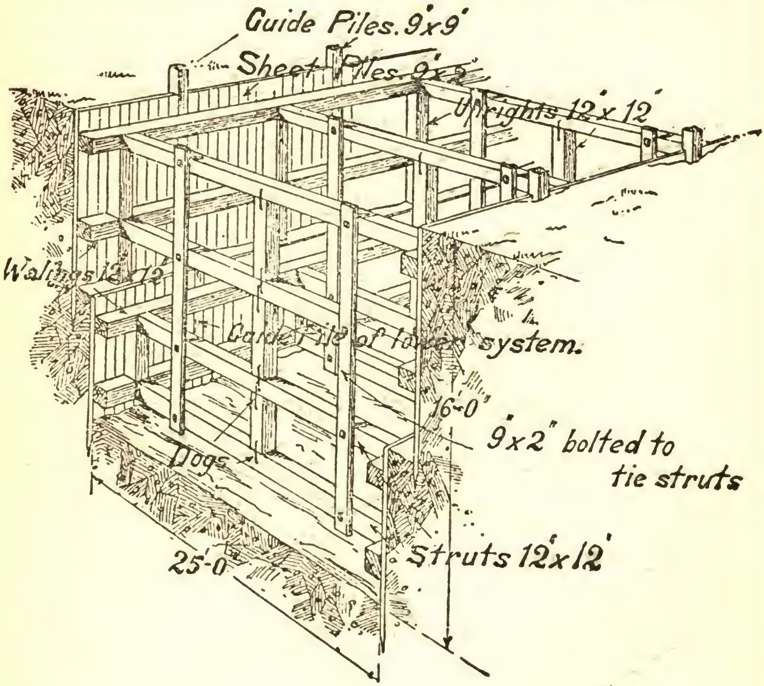


Fig. 15.

nary sheeting, but if the cuttings are required to exceed 30 ft. in width, it is found to be more economical to adopt a system of raking shores.

The method illustrated in Figs. 16 and 18 is employed where the ground is soft and waterlogged,

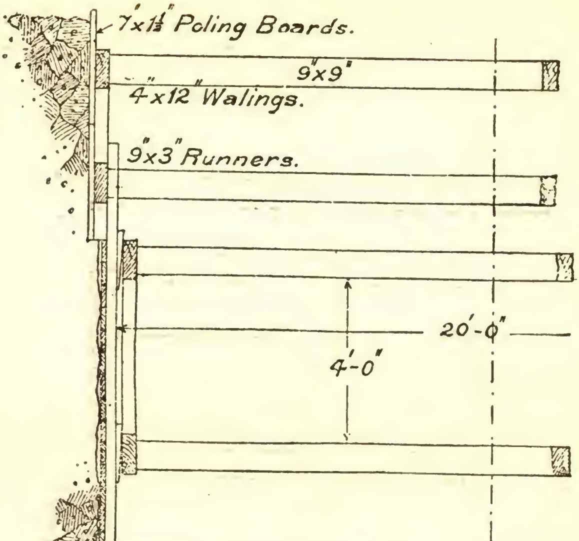

7"x1½" Poling Boards.
9"x9"
4"x12" Walings.
9"x3" Runners.
20'-0"
4'-0"

Fig 16.

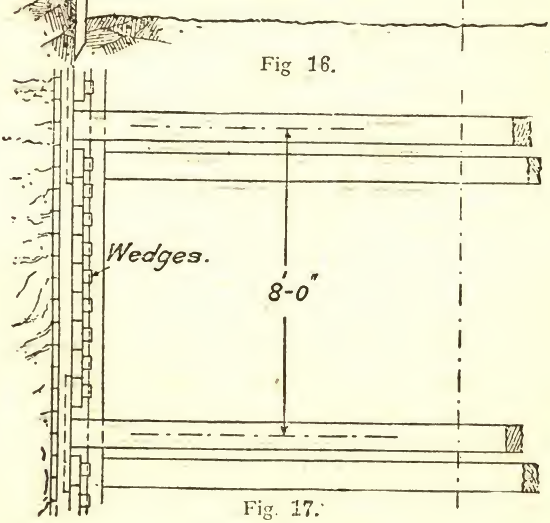

Wedges.
8'-0"

Fig. 17.

and is especially suitable for running sand. By this method as much of the earth is taken out as is possible without the sides of the excavation falling in, generally from 4 to 6 ft.; this is then supported by upright sheeting, waled and strutted. The excavation is continued by lining the cutting with a secondary system of runner, i.e., battens 7 × 2 in., pointed at lower ends

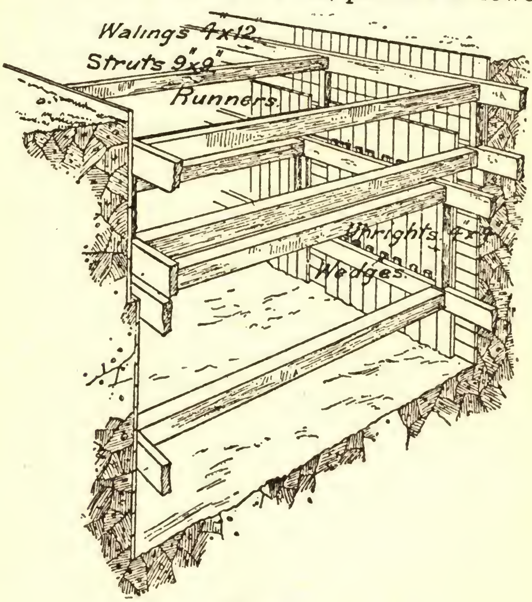


Fig. 18.

and of about 9 ft. in length. These are waled and strutted. Between each runner and waling piece a wedge is inserted. The method of proceeding with the excavation is as follows: The wedges securing one runner are loosened, the earth from the foot removed to a depth of about 12 in., the runner being dropped as the ground is removed and re-wedged. Each runner

is successively treated in this manner till the whole system has been lowered the necessary amount. It is essential that the feet of these runners should be at all times kept in the ground, as, if any portion of the vertical side of the excavation be exposed, the earth is liable to ooze out and leave the back of the runners unsupported and cause the whole system to collapse.

Sinking Shafts.—It is often necessary to sink shafts for foundations, etc. These are made from 4 ft. square and upwards, the former being the smallest size a man can work in without difficulty.

Shafts from 4 to 9 ft. square are timbered as shown in Fig. 19.

In ordinary soils the earth is excavated to a depth of at least 3 ft., and in firm soils 6 ft. The sides of the excavation are then lined with vertical sheeting, consisting of boards 9 in. wide, 1 to 1½ in. thick, strutted apart by frames of horizontal waling timbers, a pair of which is placed in position against two opposite sides, and strutted apart by another pair driven tightly between and against the remaining sides, these being secured by cleats nailed to the fixed waling pieces. Another depth of earth is then taken out and a second system of sheeting placed in, the upper ends of which lap about 1 ft. over the lower ends of the first system of sheeting; another frame is placed in position as before, securing both systems of sheeting. Uprights are fixed in the angles between the waling pieces, and often at intermediate positions along their length. This process is repeated till the required depth is obtained.

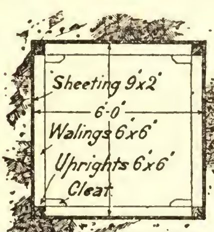


Fig. 19.

The timbering requires to be supported if the depth be great, to prevent it from sliding down on the removal of the earth from its lower end. Where this has to be done, the upper end of the shaft is left projecting about 3 ft. above the ground level. The two first fixed waling timbers at the ground level are continued through the shaft, and project several feet on either side, a good bearing on the solid ground on both sides of the shaft being thus obtained, as shown in Figs. 20 and 20A.

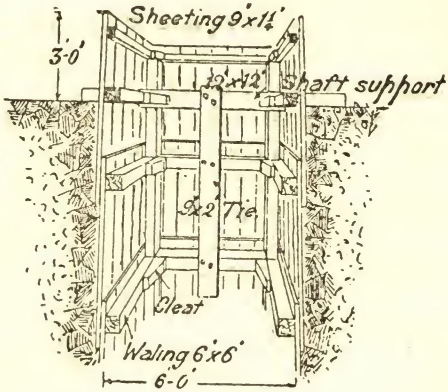


Fig. 20.

These members are usually out of square timbers; they are strutted apart as described. An upright vertical timber is notched over this, and spiked to the face of the waling timbers below, the whole being thus tied together.

These are often supplemented by similar timbers at the bottom of the shaft. These timbers are fixed in two pieces, with a scarf in the center; they project about 3 ft. into both sides of the pit. A chain is

sometimes employed in addition to the timber spiked to the walings.

Intermediate struts are required to support the horizontal walings where the size of the pit is above 9

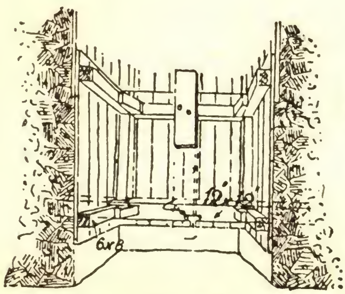


Fig. 20A.

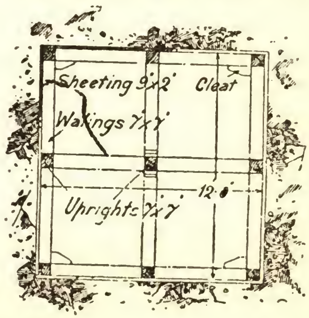


Fig. 21.

ft. square. One system of struts is fixed between two opposite sides, being supported at their ends by cleats, as shown in Figs. 21 and 23; these being necessary to prevent the timbers falling should they become loose

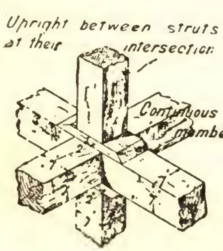


Fig. 22.

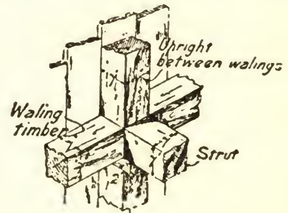


Fig. 23.

during the progress of the work. The struts that support the remaining sides intersect by butting, as shown in Fig. 22, against the first system, and are therefore fixed in two pieces. The struts at their

intersection are supported by uprights, on the upper ends of which short ends of timber are placed, projecting beyond the sides, acting as corbels, and forming a ledge upon which the shorter struts take a bearing.

The earth is raised from the bottom of the shaft, if of a great depth, by means of hoisting tackle; but if the cutting be shallow, stages are often erected in 6 ft. heights, the earth being shoveled from one to the other till the top is reached.

Tunneling.—In building operations it is often necessary to bore a tunnel in order to construct drains, etc., the process being carried out as follows:

Tunnels are made just large enough for a man to work in, that is, from 4 to 7 ft. square. The earth is taken out in sections of about 3 ft. at a time, poling boards of the same length being then placed against the upper surface, and kept in their position by a system of strutting, consisting of a head, sill and two uprights, out of either round or square timbers. The sill is placed in position first, being partly bedded in ground to prevent lateral motion, and being bedded in its correct vertical position by boning through from the sills previously bedded; the head next, then the struts, which are cut and driven tightly between the two. The next section is then cleared out, commencing at the top, just enough being taken out there to allow of the next system of poling boards being inserted, these being arranged to overlap the first system at their back end, the two being then strutted up together; this process is repeated till the tunnel is finished.

If the soil be bad and the sides liable to fall in, they must also be lined by poling boards, these being kept in their place by the uprights.

Large spikes, similar in shape to floor brads, are

driven into the head and sill, with their heads left projecting so as to be easily withdrawn, to secure the struts when in position. Wood cleats are often used in place of these.

These tunnels are usually made slightly tapering from the base to the head, as shown in Figs. 24 and 25.

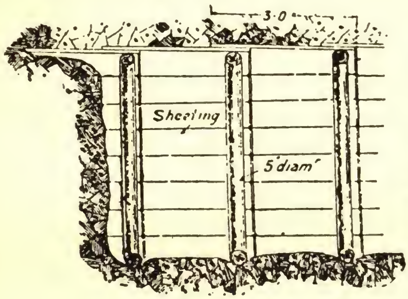


Fig. 24.

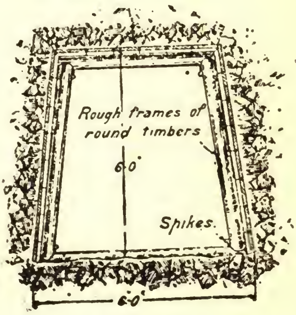


Fig. 25.

Foundations.—The construction of foundations varies with the nature and bearing strength of the soil. The following are the ordinary soils met with in practice and the method of treating them: Rock, chalk, gravel, clay and sand.

Rock.—Foundations laid upon the solid rock are undoubtedly secure, as far as settlement is concerned; such a substratum being practically incompressible. Rocks often have fissures and defective parts, and all gaps must be filled up with concrete, any unsound parts being cut away. Rock foundations are very expensive in working, owing to the extra labor involved in cutting them; but where they occur they may be built upon direct.

Chalk.—The sites for buildings on chalk or marl soil should be drained, and precautions taken to prevent

them becoming wet. Where this can be done, the structure can be built upon the chalk or marl direct, after it has been leveled; but where heavy buildings are erected, or great weights concentrated, concrete should be employed to distribute the pressure.

Gravel.—Where lateral movement is not likely to occur, gravel is one of the best soils to build upon; it is not affected by the action of the atmosphere, and is practically incompressible.

Clay.—Clay is a good soil to build upon where the foundations are taken deep enough to be beyond the action of the atmosphere. Clay is very subject to expansion and contraction with the variations in temperature, and is therefore dangerous to build upon unless protected.

Sand.—Sand is a good material to build upon, if it can be kept dry and confined laterally; if subjected to the effects of running water it is liable to be scoured from about the foundation.

In all the above soils, with the exception of the rock, and the chalk when in a good condition, it is usual to form a bed of concrete, the area of which is proportioned to the weight to be carried and the bearing strength of the soil.

The following are cases that require special treatment: (1) Soft soils of a great depth; (2) soft soils with hard strata beneath; (3) soils not having a uniform resistance, formed of rocks which have hollows or fissures filled up with some softer material. As this work is intended to be more of an elementary and practical work than otherwise, the foregoing will be quite sufficient on the preparation of trenches, cuttings and excavations for foundations, at least for the present.

In preparing footings on which to lay bricks, care must be taken to keep the work in line and fairly level on top before the brickwork is commenced, whether the lower footings be of stone or of concrete. At this writing, concrete seems to be the popular material in use for the lowest layer of foundation, and justly so, as, when properly put in place, and the proportions of the various materials wisely assigned and mixed, the work will be as though one solid stone was laid all round the building on which the brickwork may be placed. An illustration of the proper method of laying in a concrete footing is shown in Fig. 26, and one that has been adopted in many an architect's office and many a municipal building department. Taking the wall in section and extending the concrete each side of the bottom course of footings, drop perpendicular lines as outside width of concrete, the depth being determined by an angle of 45 degrees, passing from the point A of the next work, and cutting the outside line of concrete. A cubic yard of concrete would require 27 cu. ft. of broken brick, stone or shingle, 9 cu. ft. of sand, 4½ cu. ft. or 3½ bu. of Portland cement, and 25 gal. of water. These quantities should be correctly measured, turned over together three times dry, and again several times while the water, through a hose, is being sprinkled over the mass. Broken brick or stone small enough to pass through 1½-in. mesh is preferable for the aggregate. The practice of throwing in concrete from a height, in

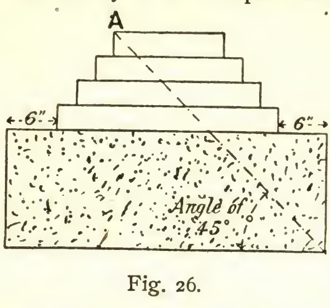


Fig. 26.

order to consolidate the mass—which used to be considered essential, even when staking had to be erected and the stuff wheeled up to the required height at considerable expense—has now exploded. It should be brought on to the side, deposited and lightly punned or beaten down with wooden rammers, but only just sufficient to bring the moisture to the surface; if rammed too much the cement comes up with the water. If, however, it is more convenient to tip the concrete into an excavation, no sensible injury will be done to it.

The objection that, in falling, the heavier particles separate from the finer is, from the very stickiness of the mass, more theoretical than practical, and, at the most, applicable only to each separate barrow load tipped in, and not to the whole bed. Sliding it down a wooden shoot, however, should never be permitted, as the cement and small stuff cling to the sides and run down in a muddy slush; whilst the stones are shot out into a separate heap by themselves.

In ordinary foundations the concrete should be deposited in horizontal layers, about 2 ft. thick, and care should be taken to cover any joints in one layer by the succeeding one, as the joint between two days' work is always a weak part; moreover, the last layer should be well wetted to insure a proper connection with the next.

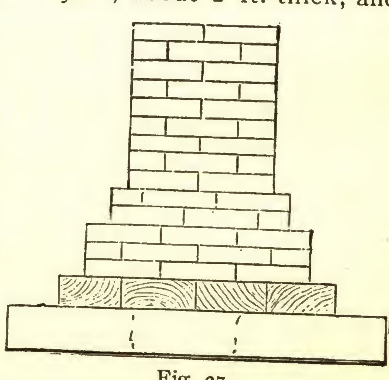


Fig. 27.

Sections of Footings and Walls in English Bond.

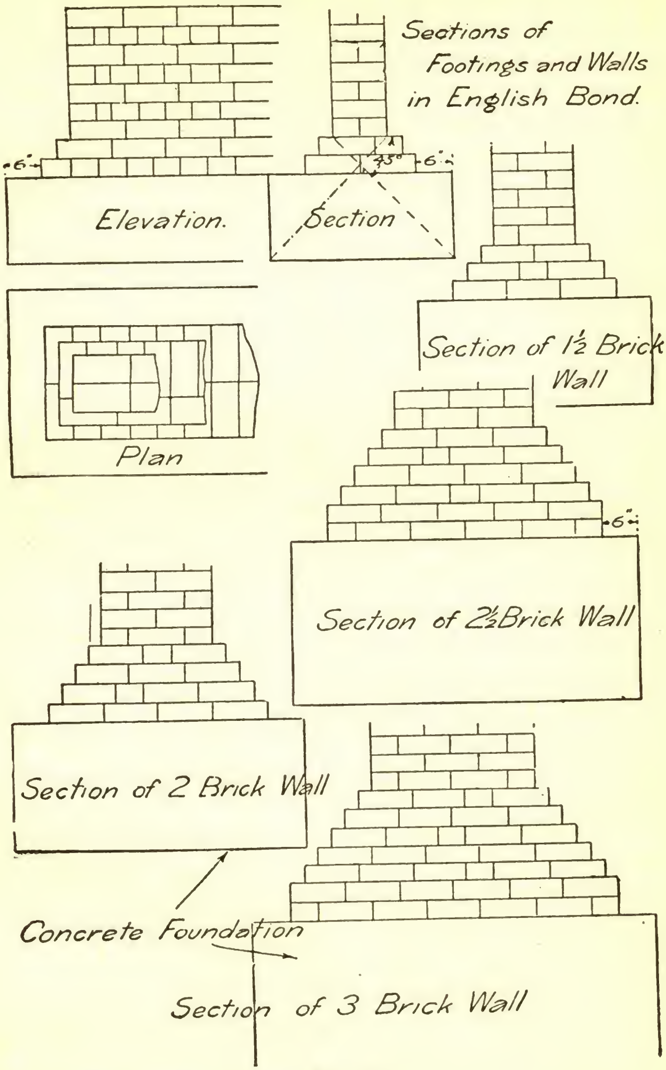


Fig. 28.

In Fig. 27 an illustration is shown of a wall and footings, the latter being of stone, not less than 6 in. thick. On the lower footing of stone is laid another course of stonework, and on this is laid the brickwork, the top of the upper stone being made level and a layer of good mortar spread over it so that the bricks have a good bed to rest on. This layer should be cement mortar where possible, as it would help to make the whole work stronger and better.

Fig. 28 shows five sections of brick walls and footings, with the methods of arranging the bricks in the wall; there being a one, a one and a half, a two, a two and a half, and a three brick wall, showing the proportions for concrete footings. A scale in feet and inches is shown on the page, so that the proper measurements may be taken off for actual use. A fact worth considering. All these examples are in English bond, but are good for any other bond.

Having dealt with foundations and footings, as we hope, in a satisfactory manner, it will not be out of place to say a few words on damp courses and means of preventing damp from getting up into the walls of buildings.

DAMP COURSES

In the construction of walls for dwellings, or in fact any other building of importance, it is essential that damp be prevented from being drawn up into the body of the wall by attraction; and the first thing to do in this case is to give some careful consideration to the floors, walls and footings of the cellar. Much has been written on the subject, and many recommendations of more or less value made as to the means of its prevention. Whether or not many of these are expe-

diencies and not cures, the conditions in each case must decide.

All building materials, with perhaps the exception of granite, are porous and capable of absorbing and transmitting moisture in large quantity. The dampness in our dwellings, however, arises from a variety of causes; from absorption of moisture from the soil in or on which the building stands (a clay soil being peculiarly bad in this respect); from imperfect joints at window sills and lintels, as also unfilled and unpointed joints on the face of the wall; from moisture, forced into the walls during heavy driving rain storms; and from the water used in the process of construction, in the mortar and plaster, the wetting of brick, etc.

Every damp-preventing device, therefore, should be twofold in nature; it should, first, preclude the moisture from getting into the walls, and second, should not hinder it from getting out of the walls. The former is to be accomplished by an absolutely waterproof covering, such as asphalt or tar, or the complete isolation of the wall from any sources of dampness (exception, of course, being made here to the moisture which is *put* into the walls in building, and which should be allowed a proper opportunity to dry out). The latter is assured by the perfect ventilation of the walls on all sides.

The remedies for the dampness arising from the several causes above noted will be studied in their proper relative places.

There are many devices for keeping moisture from entering the cellar walls, and they may be divided into applications to the outside of the wall, and constructive devices. The efficiency of the former depends, in

large degree, on the care and thoroughness with which they are applied. Of this class we have rock asphalt, tar and cements. The first and second are applied to the wall with a large brush and must, obviously, be boiling hot. The coating must be not less than three-eighths of an inch thick, covering every joint, and be carried down to the bottom of the footings. To ensure perfect protection, the wall should have been built as carefully as possible, the joints well pointed, the whole to have become well dried, and the asphalt or tar applied in two or more coats. The coatings should not stop on the face of the wall, but be carried entirely over the top, Fig. 29. Some builders recommend that the asphalt be mixed with linseed oil.

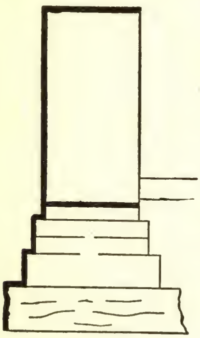


Fig. 29.

Concerning cement as a guard against water, opinions now differ. That it is an excellent protective covering when it is well and thoroughly applied is not to be questioned. It is, however, frequently fractured by the settlement of the walls, and, being to some degree porous, suffers from the action of the frost. In either case it has no further value as a protective. To lay it properly, all the joints and beds of the wall should be raked out at least one-half inch deep. The coating should not be less than one-half inch thick, and should, as far as possible, be applied all at one time. If it is necessary to make a joint it should be vertical and not horizontal. The last precaution is that the earth must not be filled in against it until the cement has thoroughly set. A similar protective

covering is made of a concrete of one-half lime mortar and one-half good cement (Portland preferred).

Of constructive devices to guard against dampness we have, first, those that are in the wall itself, and comprise the horizontal damp courses, hollow brick lining and facing and hollow wall.

The horizontal damp courses are of several kinds, and are placed at the bottom of the wall either on top of the footings or a short distance above them. The most effective course is one of asphalt or tar, Fig. 29, applied in coats in the same manner as described for the facing of the walls. A greater degree of efficiency is given by laying the course of bricks immediately above the damp course, while the last coat is still hot and soft. When this damp course is set in a stone wall it would be better to lay a course of bricks and on this place the asphalt course, starting the stonework above the latter, Fig. 30. A layer of slate, set in cement, has been much employed as a damp course. It has, however, the disadvantage of being very liable to fracture under uneven pressure. Sheet lead is a most excellent damp course, and has been applied to the purpose for two centuries. For ordinary work its cost precludes its use.

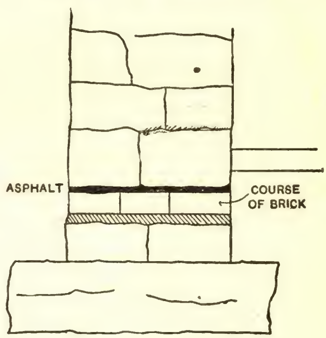


Fig. 30.

It is claimed that the penetration of moisture can be hindered by building the wall so that there are no continuous bed joints through the wall. This device

is presented on its own merits, the writer having no personal knowledge of its efficiency.

Another excellent damp course is found in the use of perforated terra-cotta bricks. These are made the same size as the ordinary brick, and can, therefore, be readily bended into the wall. A course may be set immediately above the footings and another at or near the top of the wall. The bricks should be laid so that the openings run through the wall and so allow of ventilation and evaporation of any moisture that might

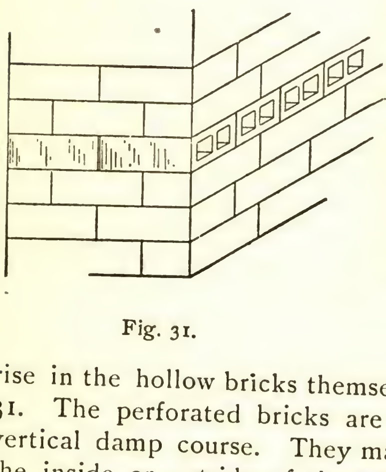
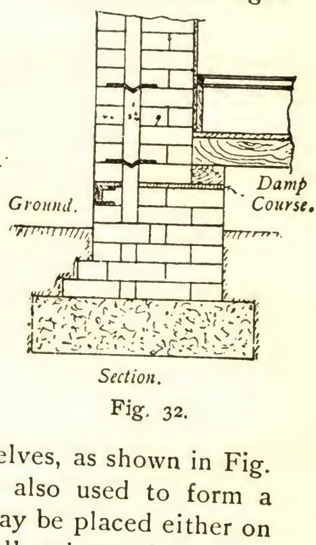


Fig. 31.



Section.

Fig. 32.

rise in the hollow bricks themselves, as shown in Fig. 31. The perforated bricks are also used to form a vertical damp course. They may be placed either on the inside or outside of the wall and may be laid as stretchers, as there is not the same liability to collect and retain moisture as there is in the horizontal course. Headers should be placed at frequent intervals to bond the facing to the body of the wall.

A simple and somewhat inexpensive system of rendering walls absolutely damp-proof and of adding very

much to their strength and stability is to build the brickwork in two 4½-in. thicknesses with a ½ or ¾-in. cavity kept clear of mortar. Thin boarding is inserted in the cavity as the work advances, the space being afterwards filled with rock asphalt compositions. The compositions answer the double purpose of binding the two thicknesses together and making the wall impervious to moisture. A section of such a wall is shown in Fig. 32.

As a rule damp-proof courses should be 6 in. or more above the level of the external ground, but, where possible, under the wall plate carrying the joints for the floor.

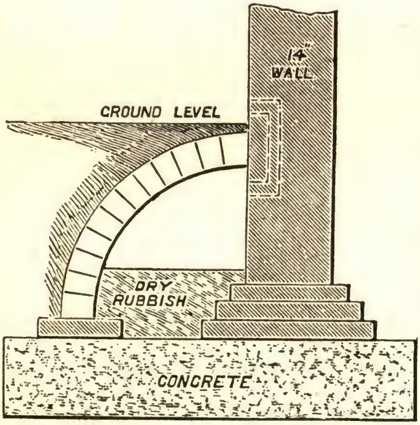


Fig. 33.

In buildings finished with a parapet wall, a damp-proof course should be inserted just above the flashing of the gutter, so as to prevent the wet which falls upon the top of the parapet from soaking down into the woodwork of the roof and into the walls below.

In some localities damp-proof courses are formed with slates set in cement; these are rather liable to crack, and thin impervious stones are better. Sheet lead has been used for the same purpose, and is most efficacious, but very expensive.

Arches are frequently rendered all over the extrados

with asphalt or cement to prevent the penetration of wet, same as shown in Figs. 33 or 34. In addition to the precaution adopted to prevent damp out of the ground from rising in walls, it is necessary (especially when using inferior bricks or porous stone) to prevent moisture falling upon the outer face from penetrating to the interior of the wall.

The wet may be kept out of the interior of the wall by rendering the exterior surface with cement, covering it with slates fixed on battens or with glazed tiles set in cement; glazed or enameled facing brick answer the same purpose.

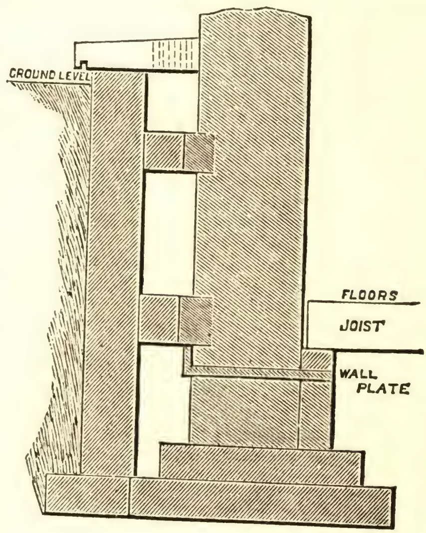


Fig. 34.

Sometimes vertical damp courses are used as shown in Figs. 34 and 35, particularly when the ground outside is higher than the wall plate inside, to prevent the damp penetrating through the wall. It will be seen that the damp course is bedded in the wall directly under the wall plate; this prevents the damp rising and destroying the wood. The vertical damp course acts in a similar manner in excluding the damp through the side of the wall; the joints of brickwork should be raked out to receive this damp

course Fig. 35 shows a good method of keeping damp out of the main walls. When the ground level is higher than floor level it will be seen that a 4½-in. wall is carried up to the ground level and covered on top with a stone coping fitted with an iron ventilating grating. By this method, as the damp penetrates through the 4½-in. outer wall, it rises and passes through the grating and into the open air. This wall is carried about 4½ in. from the face of main wall, and bonded into main wall as shown. Where the bonds enter, the main wall is tarred to prevent any damp entering.

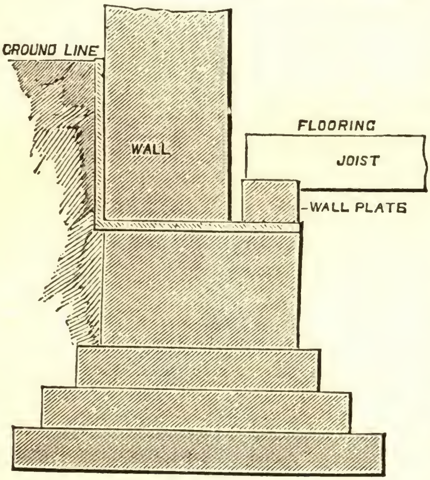


Fig. 35.

Another method of preventing damp from getting into a wall is to adopt what is known as the "dry area method," which is simply the building of a dwarf wall all around the building and leaving a space of two or more feet between the dwarf wall and the walls of the building as shown in Fig. 36. It will be seen by sketch that the ground is excavated to a width of 2 ft. from main walls and the dwarf wall built as shown to keep the water away. This area is necessary in damp situations, as any moisture or wet is carried away by a drain that is laid under the area, thus keeping the

main structure dry. The dwarf wall is finished with a brick-on-edge coping built in cement. The floor of area is usually covered with cement concrete paving to prevent the water soaking in. Fig. 33 shows an enclosed dry area formed by means of the arch; this area is drained as in Fig. 34, and the moisture is carried through the flue, as shown by dotted lines, into the open air. This flue is lined either by neat cement or by asphalt to prevent the moisture penetrating into the wall. Hollow or cavity walls should be used for external work in damp situations exposed to driving rains. Such walls are of brick or stone, with a cavity of 2 or 2½ in. The external wall should be 4½ in., the thicker portion being inside; false headers being used in the outer wall.

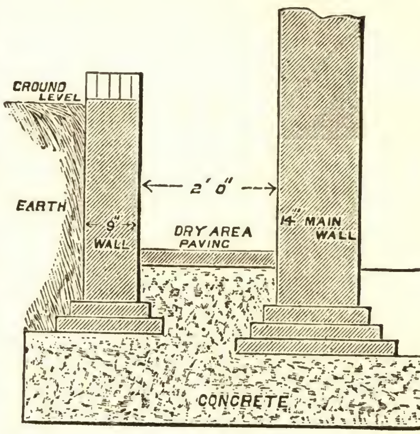


Fig. 36.

The thick wall inside will carry the doors and roofs, the woodwork being kept clear of the outer portion, which is liable to be damp.

The cavities should be ventilated by air-bricks in the external portion at top and bottom. Care must be taken that no mortar or other drippings get into them; movable boards or hay bands should be used.

The wall ties, generally of cast or wrought iron, galvanized or well tarred and sanded, should be employed

to tie the two walls together; or, better still, a tie or bonding brick, which is made for this purpose, may be used as shown in Figs. 37 and 38. Walls constructed after this method not only exclude the damp, but the layer of air they contain, being a nonconductor of heat, tends to keep the building warm. Such walls are formed in two separate portions, stand-

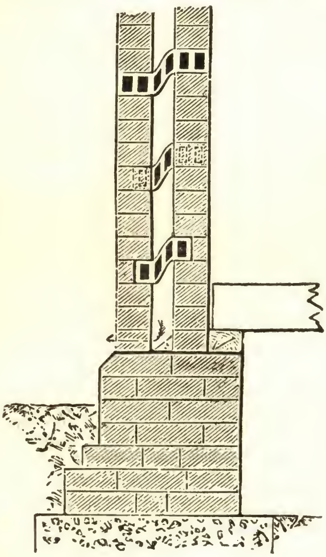


Fig. 37.

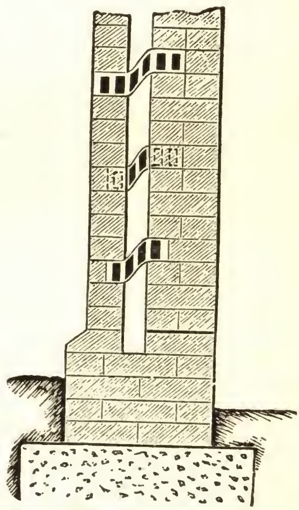


Fig. 38.

ing vertically parallel to one another, and divided by a space of about 2 to 3 in.

There are several ways of arranging the thickness of the portions of the wall, and the consequent position of the air space.

In some cases the two portions are of equal thickness, the air space being in the center, as at Fig. 37.

Very frequently one of the portions is only 4½ in. thick, built in brickwork in stretching bond; the other is of such thickness as may be necessary to give the whole stability, as in Fig. 38.

In such a case the thin 4½-in. portion is sometimes placed on the outside, and sometimes on the inner side of the wall.

In some cases, such for instance as when the wall has a stone face, the 4½-in. portion is necessarily on the inside, but this arrangement has many disadvantages.

In the first place, the bulk of the wall is still exposed to damp, and the moisture soaks in to within 7 or 8 in. of the interior of the building.

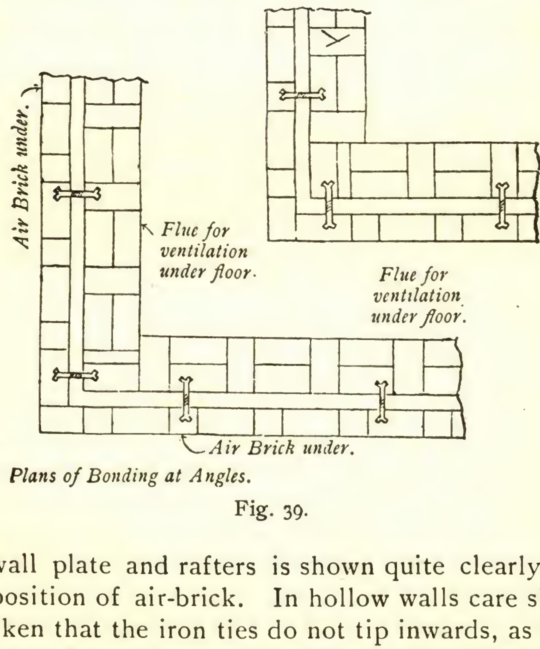
Again, if the wall has to carry a roof, expense is caused, as the span should be increased so as to bring the wall plates on to the outer or substantial part of the wall, clear of the 4½-in. lining.

This may be avoided by bridging over the air space, so as to make the wall solid at the top, which, however, renders it liable to damp in that part.

On the other hand, if the 4½-in. portion is placed outside, the damp is at once intercepted by the air space, kept out of the greater portion of the wall, and at a considerable distance from the interior of the building, and the thicker wall then carries the joists, also the whole weight of the roof.

The following illustrations, Figs. 39, 40, 41, 42, 43 and 44, show how a hollow wall should be constructed in order to have it substantial and effective. Fig. 39 shows how the angles should be bonded to secure good substantial work, also the position of the air-bricks to secure good ventilation. Fig. 40 shows how to bond the work around fireplace openings, flues and other

similar work. In Fig. 41, sections of a window and doorway are shown, also an elevation of brickwork with door and doorway in which are shown the positions of the metal ties marked by the little crosses. Fig. 42 shows a plan of the doorway bonded with ties. The elevation of wall shown in Fig. 43 illustrates the positions of the ties, also of the air-brick. In Fig. 44 the manner of finishing the top of the wall to take in



Plans of Bonding at Angles.

Fig. 39.

the wall plate and rafters is shown quite clearly, also the position of air-brick. In hollow walls care should be taken that the iron ties do not tip inwards, as water will in such case traverse even the double twist usually employed. The better shape has a V drip in the middle. To prevent the wet which may enter the air space dripping on the window or door frame, a piece of sheet lead is built in on the inner side of the 4½-in. exterior

wall, 1½ in. turned up and carried about 2 in. farther than the ends of the lintel.

There is another method sometimes resorted to because of its cheapness, and which, in some cases, proves quite effective where the ground is dry or composed of sand or gravel, and that is to lay common field tiles or weeping tiles all around the walls both inside and outside and connect them by drain tiles to the sewage system or to some low spot, where the drainage will be effective.

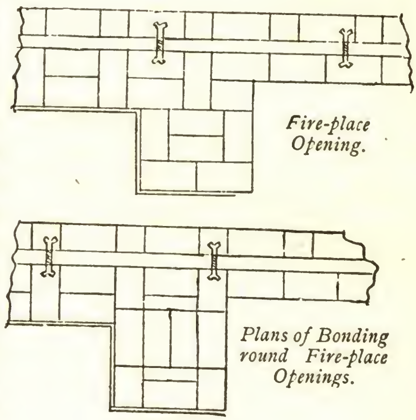


Fig. 40.

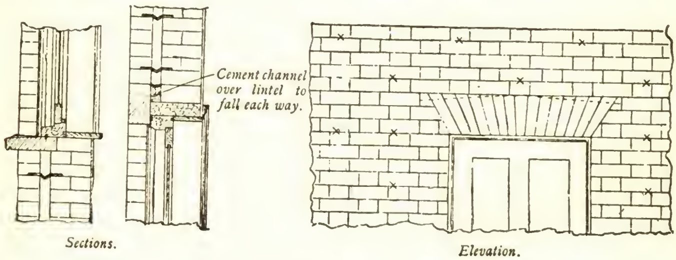


Fig. 41.

These weeping tiles should be on a level with the footings of the building and even lower when possible, to get a good fall so that the water will drain off readily.

It will be understood that the dampness of walls is usually owing directly to the absorbent qualities of the

materials of which they are composed and hence houses built of inferior bricks, which are always absorbent to a considerable extent, cannot be expected to be dry, and especially if they are in isolated positions, where the walls are exposed to the full blast of the weather. Even where good materials are employed, the same effects may be noticed in exposed buildings.

The best construction for a brick building in such positions is the employment of the hollow walls, as shown in the foregoing, which should be carried up throughout the whole of the structure. Their efficiency depends, as in the case of the area walls, upon

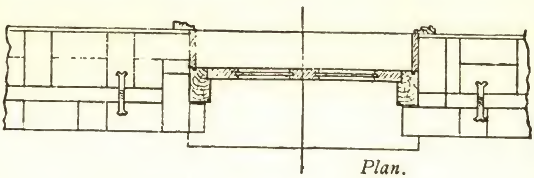
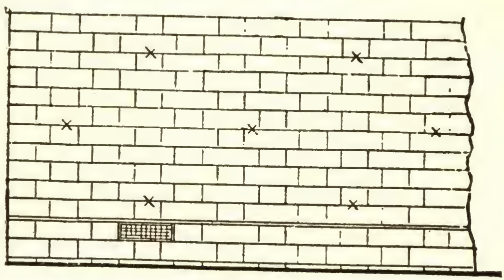


Fig. 42.

forming a cavity. A damp-proof course should also be provided, and may with advantage be made on the level of the cavity gutter, so as to answer for the two purposes. The few courses of bricks between the damp course and the footings may be built solid, the bricks being cut to form the necessary width. Various ties for connecting the casings are in the market, two of which are represented in the illustrations. That formed of brick is moulded so as to rise a course front to back to prevent the water from creeping along it, and the iron tie is provided with a middle indentation for the same purpose.

Properly constructed, these cavity walls are quite

effectual in rendering a building dry. They should always be employed for buildings standing by themselves. Strips of lead, tin, zinc or other metal must be placed over all door and window openings, being bent so as to throw any water falling upon them into the gutter below. Cavity walls cost very little more than solid ones. The quantity of bricks used in the construction is almost the same, the only extra materials being the ties and the guttering. Besides keeping the building dry, hollow walls have the advantage of rendering the interior of the house less affected by



Elevation.

Fig. 43.

changes in the temperature, rendering it cooler in the summer and warmer in the winter, a considerable advantage in a variable climate like this. The hollow space, moreover, lends itself very readily for the purposes of ventilation.

Dampness will sometimes be found to arise from the soil below the floor, and in building upon such soils the whole site should be covered in, beneath the lowest floor, with dry earth, or, better still, with a thin layer of concrete, which will prevent the damp rising from that source.

Referring now to the cure of damp buildings, it will nearly always be found to be at the best a troublesome matter. Sometimes the building will have been erected without a damp course, and the insertion of one by underpinning all around the building will, in such cases, generally effect a cure; or it may penetrate through the walls, either in the case of a cellar wall, from the earth resting against it, or from the rain beating through in the stories above. In the first case it may be removed by digging away the soil around the building and erecting a dry area wall, such as that before referred to, but as this is always quite an expensive way a simpler method may be tried. See that the earth around the building is properly graded, construct small air shafts at frequent intervals, inserting air-bricks above the ground line so as to place the space beneath the floor in direct communication with the outer air. This may be sufficient of itself, but if the wall is plastered and still shows signs of dampness, proceed as follows:

Hack off all the plaster from floor to ceiling. Place a stove in the middle of the room and keep up a large fire, night and day, until the walls feel quite dry to the hand. Then render the walls in plaster composed of nearly neat Portland cement.

Many obstinate cases have been cured in this manner. Re-rendering the plaster is expensive, and various paints and washes are in the market for application to the face of the plaster to keep out the damp. Some of them are effective, but the success of all depends upon the very simple precaution of stripping the whole of the paper from the walls and getting them dry before applying the wash or paint. In some cases the dampness will be found to rise some 2 ft. only from

the ground, and a cure has been attempted by painting the wall or applying lead foil beneath the paper to that height; but the method is useless, for the damp will only rise and show itself above the line of foil or paint.

In outside walls dampness will sometimes show itself in small patches here and there, and sometimes in quite large patches. The small patches probably arise from a few bricks of inferior quality which have inadvertently been built in the wall, and a cure can generally be brought about by covering the space on the inside of the wall beneath the paper with lead foil, using it to cover a space about 6 in. beyond the actual space of dampness. Where large spaces on the wall show damp, it may arise from defective gutters, from bad bricks, want of pointing, or other causes. Remove the cause, if possible, and if that cannot be done, the following remedy will prove of use. Melt 3 lbs. of strong soap in 4 gal. of water, and carefully apply to the wall, so as not to produce a lather. Mix ½ lb. of alum with 4 gal. of water, allow it to stand for 24 hrs. (by which time the soap will be in a condition to receive it), and carefully apply as before.

The following is said to be quite effective in keeping out damp, when properly applied to outside walls: Soft paraffin wax, 2 lbs.; shellac, ½ lb.; powdered resin, ½ lb.; benzoline spirit, 2 qts.; dissolve these by gentle heat in a water bath, then add 1 gal. of benzoline spirits and apply warm. The mixture is very inflammable, and must be kept away from the fire. We may mention here another method of making brickwork impervious to water, known as Sylvester's process, which was used with success on the Croton reservoir, Central Park, New York. It consists in the

successive application to the walls of two washes, one composed of Castile soap and water, and the other of alum and water. The proportions are ¾ lb. of soap to 1 gal. of water, and ½ lb. of alum to 4 gal. of water. The walls should be quite dry and clean, and the temperature of air not below 50 degrees Fahr. The soap wash is laid on first with a flat brush and at a boiling heat. After 24 hrs. the wash becomes dry and hard, and the alum wash is applied at a temperature of 60 to 70 degrees Fahr. This is allowed to remain 24 hrs., when the operation is repeated until the wall has become impervious to water. The number of applications required will depend on the water pressure to which the wall is subjected.

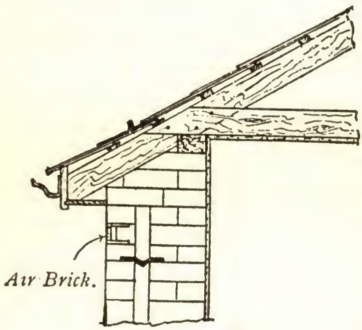


Fig. 44.

In the Croton reservoir cases, four coatings were found to render the reservoir free from leakage under 40 ft. head. This is similar to the recipe given in another paragraph. Resin has been used also as a protection against moisture. Five parts of turpentine, heated and stirred in ten parts of pulverized common glue, and one part of finely-sifted sawdust are then applied to the wall, which should be cleansed and heated by means of a lamp, so that the composition may run into every crack and joint. Very often a cement lining is of no use to make a tank water-tight, especially where the bricks and joints are of an inferior description, and the aim should be to get a composition which, when heated,

enters the pores of the brickwork and renders them impervious.

The top of a wall also may be as likely to admit dampness as the bottom or sides, if it is not properly protected by the roof or by proper copings; as the rain, sleet and snow are liable to soak down into the body of the brickwork and cause damp and decay.

Copings may be of a variety of shapes and materials, stone, copper or other sheet metal, terra-cotta tiles, brick or cements. If bricks are employed, good Portland cement mortar should be plastered over it, cover-

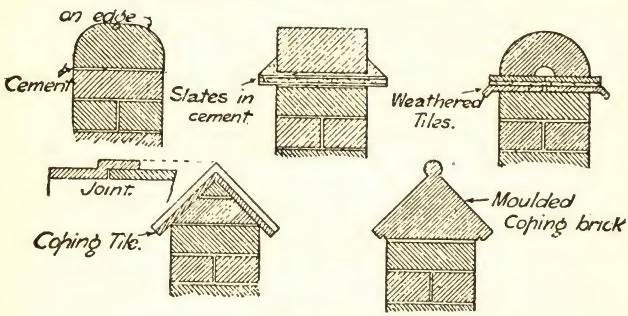


Fig. 45.

ing it at least an inch deep. A number of copings are shown in Fig. 45. The first illustration shows a wall covered with a half-round pressed brick laid in cement mortar. The other illustrations show for themselves.

There will often occur cases where it will be expedient to support loads by the method of brick corbeling, which consists of one or more courses projecting the required distance from the wall.

There are two points that have to be considered in corbeling. The first is, that as every projecting brick is acting as a cantilever the end of the brick should be

tailed into the wall as far as possible. To obtain this, as many headers as are available are used. Secondly, the projection of every course over the one below should not exceed 2¼ in.; but it is better if it is only 1⅛ in. Corbeling renders the walls less stable by bringing the center of gravity of the mass nearer the internal edge of the wall. Figs. 46 and 47 give two examples.

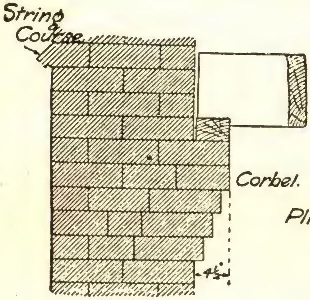


Fig. 46.

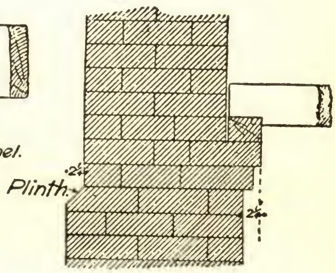
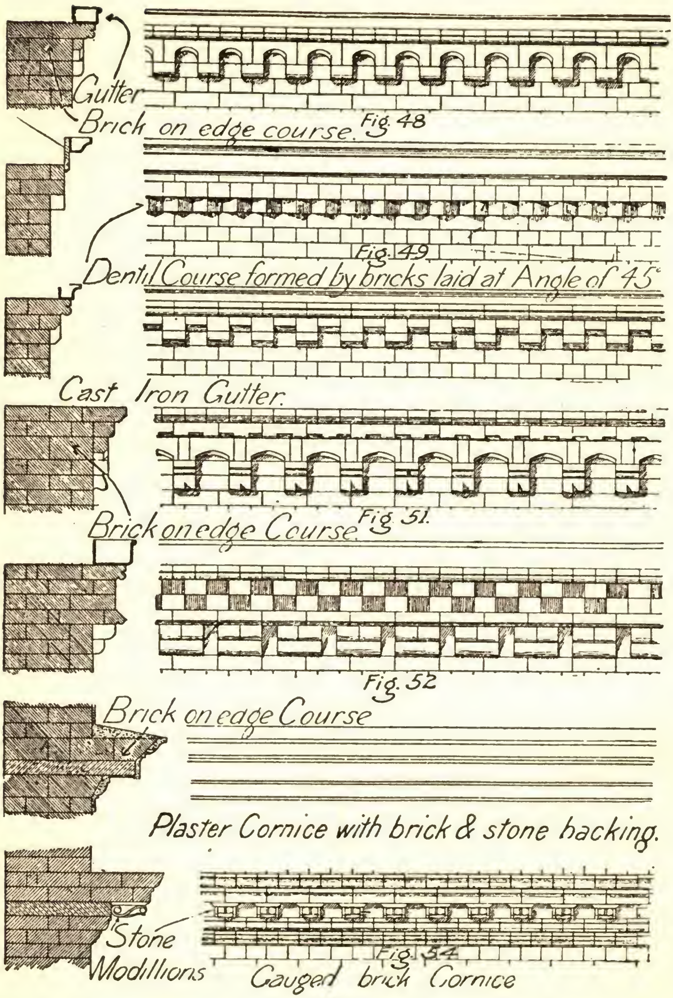


Fig. 47.

BRICK CORNICES

Brick cornices are carried out on the principles of corbeling, the length of bricks being 9 in. No cornice made entirely of bricks should project more than that amount. This being accepted, bricks are more suitable for the large projecting cornices of buildings treated in the classic styles. Wherever bricks are employed in the latter styles, if the cornice has modillions, the latter are usually of stone of a color resembling the bricks and well tailed into the wall, thus forming a support for the crowning courses, as shown in Fig. 48. Fig. 49 shows the brick backing for a plastered cornice; the large projection is also here obtained by the use of stone. Bricks are more suitable for cornices of buildings of the Gothic styles,


Gutter
Brick on edge course.
Fig. 48
Fig. 49
Dentil Course formed by bricks laid at Angle of 45°
Cast Iron Gutter.
Brick on edge Course.
Fig. 51.
Fig. 52
Brick on edge Course
Plaster Cornice with brick & stone hacking.
Stone
Modillions
Fig. 54
Gauged brick Cornice

which usually resolve themselves into a moulded band supported by a corbel table, as shown in Figs. 50 to 54. In either variety there is no detriment in placing the bricks on edge wherever the dimensions of the members or disposition of the arts render that arrangement necessary.

Another style of cornice, in which moulded bricks are used, is shown in Figs. 55 and 56. In setting this out, convenient lengths should be taken, e.g., from

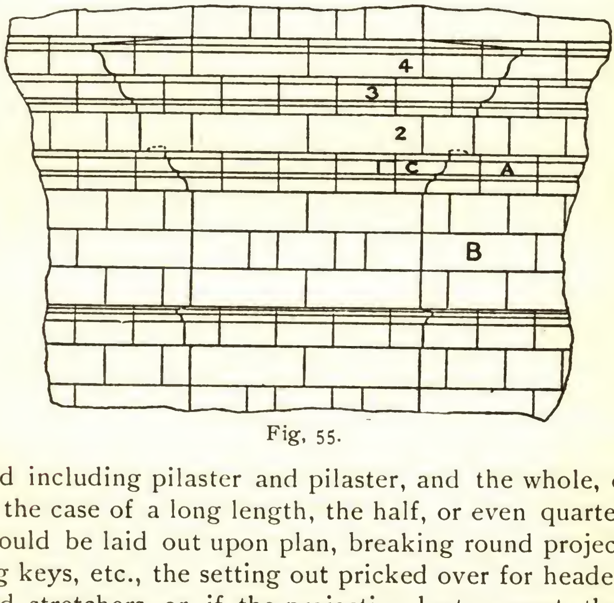


Fig. 55.

and including pilaster and pilaster, and the whole, or in the case of a long length, the half, or even quarter, should be laid out upon plan, breaking round projecting keys, etc., the setting out pricked over for headers and stretchers, or, if the projection be too great, then for headers only, so as to get an exact number without broken bond. It may occur that the headers and stretchers are slightly over or under 4½ and 9 in.; but, whatever the size, a gauge is cut to it, and the headers and stretchers reduced to the gauge. The bricks

should be joggled, and the work properly run in with Portland cement. All internal miters, stopped returns, etc., in cornices should be solid. Some brick cutters make cut miters, putting them together dry, as being an easier method; but this is not correct work.

It will be noticed in Fig. 55 that the cornice is continued round, and forms a cap to the pilaster; the principal perpends in the plain work of this and of the general face work being continued through the cornice as far as possible. The breaking out of the returns

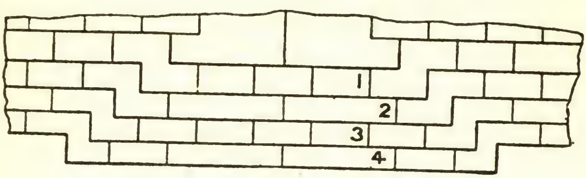


Fig. 56.

round the pilaster and the bonding between the latter and the straight run of cornice is made out where necessary in between. Thus taking course I of the cornice in elevation, Fig. 55, the brick A pairs with the plain brick B, which goes home to the pilaster. If A did the same, then a joint would occur immediately over the angle of the pilaster, and the return would appear as if it were merely stuck on, which would be unsightly; hence, to remove the joint from this point, A becomes a bat header, and a solid return is obtained in the three-quarter bat C, which, on account of projection, as will be seen upon plan, is made out by a brick shellacked to the back of it. As already stated, it is sometimes necessary for headers only to be used in cornices. This applies with greater force to the top course, where they are frequently

beveled to form a weathering. The bonding of the courses 1, 2, 3 and 4 upon elevation agrees with those marked 1, 2, 3 and 4 upon plan. (See Fig. 56.)

In making plain pilasters and cutting and setting them out, but little more skill is required than that of gauging bricks for a Gothic arch, unless they be fluted or seeded, or both; then a pair of moulds cut to the plan of the pilaster should be used; the brick being worked in the box face upwards, the back of the brick on the bottom of the box being roughly squared. The difficulty lies in setting out the proper bonding of the base and cap. The full-size plan and elevation of each should be worked in conjunction with a few courses of the plain work; the bond accurately set out, and the work cut according

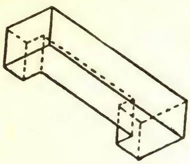


Fig. 57.

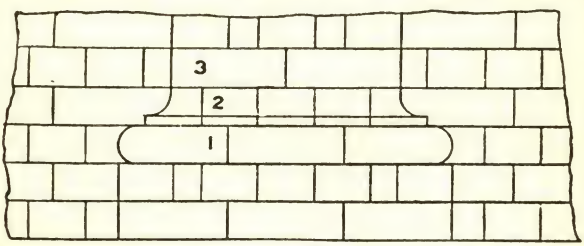


Fig. 58.

to it (see Figs. 58 and 59, which represent the elevation and plan respectively of the base). Here it will be noticed that the bonding of the plain work of the pilaster and also the general face work is kept as far as possible, courses 1, 2, 3 of the elevation agreeing with 1, 2, 3 of the plan. The cap of the pilaster is taken in conjunction with cornices.

Pilasters vary in shape upon plan, and the correct

bonding must be dealt with as the cases occur; but an instance is given in Figs. 60 and 61 of a half-octagonal pilaster, and in Figs. 62 and 63 of a half-hexagonal.

It frequently happens that the bricklayer has to panel a wall under windows, in gables and other similar places, and in order that the workman may be

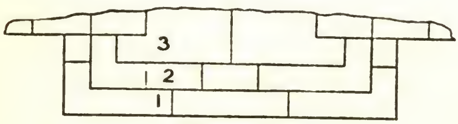


Fig. 59.

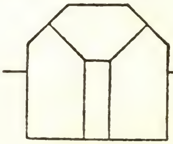


Fig. 60.

prepared for such work the following has been selected which gives a few instructions on the subject, and which will be found simple and easy to follow:

In setting out panels, the height is usually kept in courses with the general work; but the width is not always the multiple of a 9-in. stretcher, and needs consideration. Set up a quarter of the panel, what-

Fig. 61.

Fig. 62.

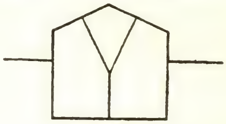


Fig. 63.

ever the width, including the moulding, and prick over for headers and stretchers. Let Fig. 64 be a quarter of a panel, measuring 4 ft. in width. Had the width been 3 ft. 9 in., it is very clear that five 9-in. stretchers would exactly fill it; but, as it is 3 in. over this, divide the 3 in. equally among the five stretchers, making them slightly over 9 in., and the headers and closers in proportion. The joints will be arranged as in Fig. 64; the mould for the side stretchers, e.g.,

A B, etc., will be as in Fig. 65, one side of the brick being roughly squared and placed on the bed of the box; thus the brick will be worked on edge with the moulding upwards; the moulds for the top and bottom horizontal moulding being as in Fig. 66, and

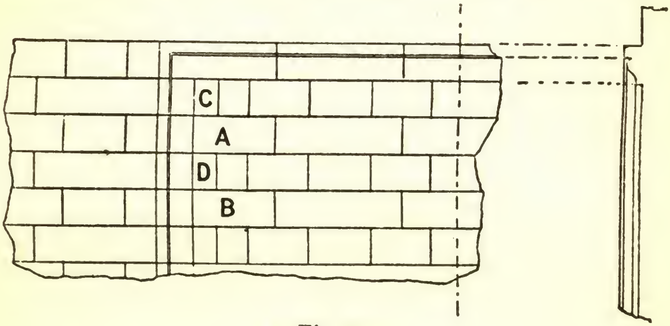


Fig. 64.

worked with the roughly squared bed of the brick on the bottom of the box, the moulding again being upwards. The side headers C D, etc., will require another pair of moulds (Fig. 67), the brick being placed in the box on edge and moulded on the end.

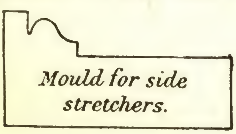


Fig. 65.

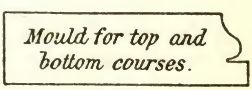


Fig. 66.

All angles should be cut in the solid brick, with no mortar joint.

A projecting key is sometimes adopted in an arch as an ornamental feature, when some few of the center bricks, including the key-brick and those adjacent, are made to stand out from the general face of the arch;

sometimes being also moulded (Fig. 68). Whatever size the block may be at the top, it is divided into odd courses; thus 8 in., 9¼ in., etc., would make three courses, 14 in. five courses, etc., the course being cut to the same template as those for the rest of the arch, though, if necessary, to a different cutting mark. If the projecting key is also to be moulded on the face, as Fig. 68, the bricks are first cut to the template, the depth and thickness being properly arranged and bonded (Fig. 68 and 69, which show one course in definite and the other in dotted lines), then set, or "blocked" as it is practically known, together with white lead and shellac, and afterwards cut in the box, face upwards, in the same way as ordinary mouldings.

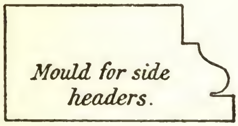


Fig. 67.

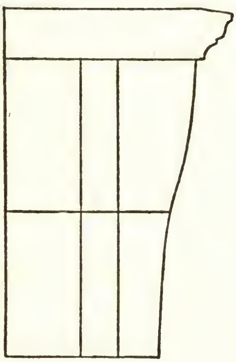


Fig. 68.

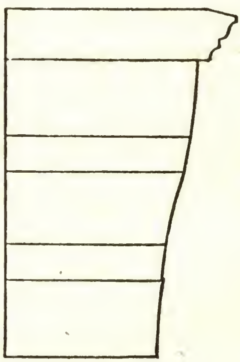


Fig. 69.

There are many other difficult and interesting details in ornamental brickwork, which it is hoped will be treated upon in some future work.

BONDING

The question of "bond" is one of the most important in brickwork, yet few bricklayers give much attention to this department of this work. They generally follow certain rules customary in the locality in which they reside, or methods they learned during their apprenticeship.

Bond (that is, to bind) is the name given to any arrangement of bricks in which no vertical joint of one course is exactly over the one in the next course above or below it, and having the greatest possible amount of lap.

Bond in brickwork is the method of arranging each brick so that it laps over the bricks with which it is in contact above and below a distance equal to one-quarter of the length of the brick. To ensure good bond the following rules should be rigidly adhered to: First, the arrangement of the bricks must be uniform, and as few bats as possible be employed; second, a closer to be inserted after the quoin header in any course; third, the vertical joints in every other course to be perpendicularly in line on the internal as well as the external face; fourth, stretchers are only to be used on the faces of the wall, the interior to consist of headers only, except in footings and corbels; fifth, the dimensions of bricks should be such that, when bedded, the length should equal twice the width plus a mortar joint.

Hindrances to good bond often occur when facing or pressed bricks used are costly or of different lengths and widths to the body of the wall; in 9-in. walls, where it is necessary to have two fair faces, very frequently facing both on the outside and inside.

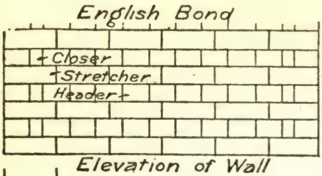


Fig. 69½

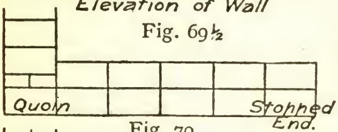


Fig. 70.

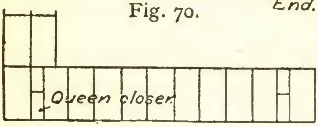
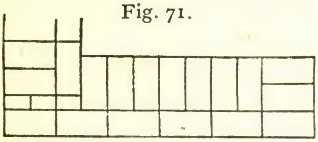


Fig. 71.



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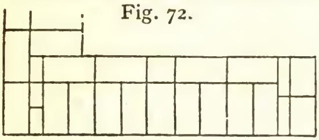

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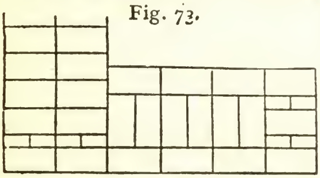

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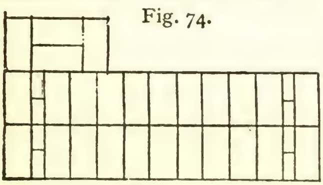
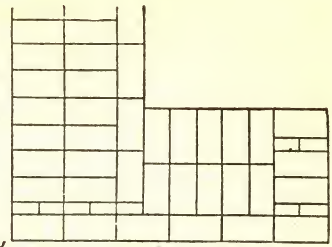


Fig. 75.



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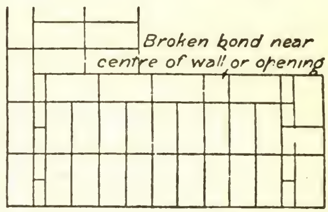


Fig. 77.

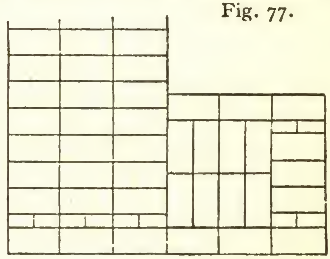


Fig 78.

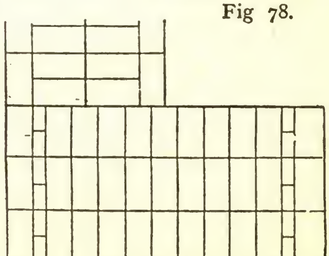


Fig. 79.

Figs. 69–79. Examples of English Bond.

There are several kinds of bond used in brickwork, among which we may name: first, English; second, double Flemish; third, single Flemish; fourth, English cross; fifth, Dutch; sixth, stretching or chimney; seventh, heading bond; eighth, country or garden-wall bond; ninth, raking bonds; tenth, hoop-iron bond. When the bond is arranged as shown in elevation and plan Figs. 69½ to 79, it is known as English bond, and sometimes old English bond. It consists of one course of headers and one course of stretchers alternately. In this bond, bricks are laid as stretchers only on the boundaries, of course, thus showing on the face of the wall, and no attempt should be made to break the joints in a course running through from back to front of a wall. That course which consists of stretchers on the face is known as a stretching course, and all in course above or below it would be headers with the exception of the closer brick, which is always placed next to the quoin header to complete the bond, and these courses would be called heading courses.

It may be noticed that in walls, the thickness of which is a multiple of a whole brick, the same course will show either:

(*a*) Stretchers in front elevation and stretchers in back elevation.

(*b*) Headers in front elevation and headers in back elevation; but in walls in which the thickness is an odd number of half bricks the same course will show either:

(*a*) Stretcher in front elevation and header in back elevation.

(*b*) Header in front elevation and stretcher in back elevation.

In setting out the plan of a course to any width,

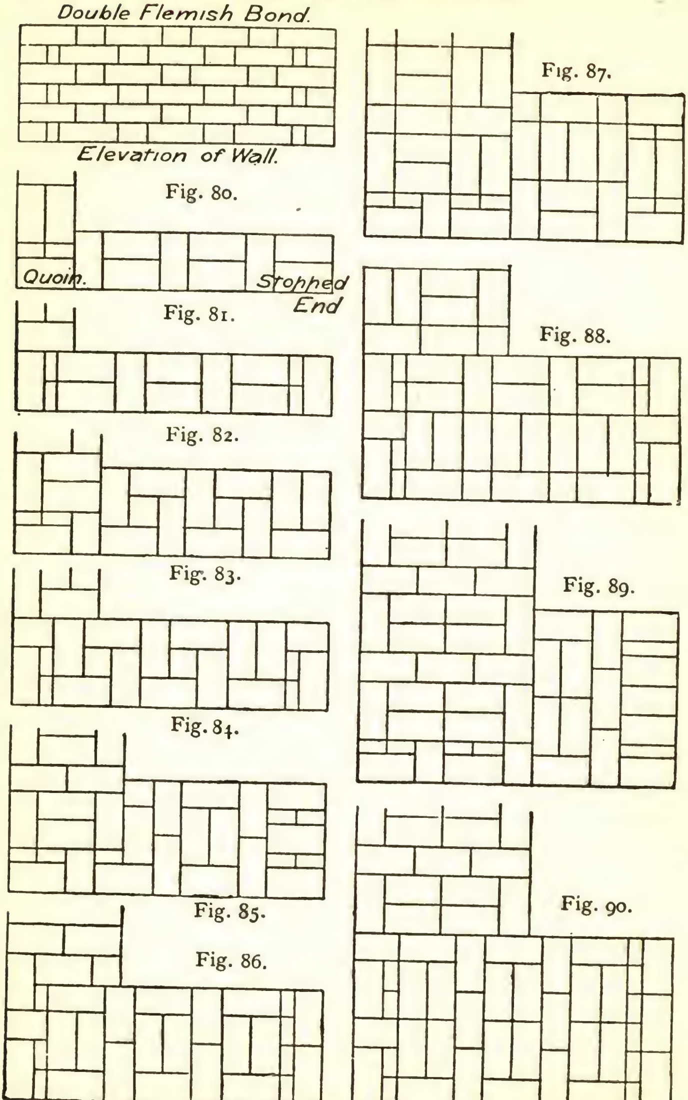


Fig. 80–90. Examples of Double Flemish Bond.

draw the quoin or corner brick; then next to the face (which in front elevation shows headers) place closers to the required thickness of the wall, after which set out all the front headers, and if the thickness is a multiple of a whole brick, set out headers in rear; the intervening space, if any, is always filled in with headers.

Double Flemish bond has headers and stretchers alternately in the same course, both in front and back elevations, as shown in Figs. 80 to 90. It is weaker than English bond, owing to the greater number of bats and stretchers, but is considered by some to look better on the face. It is also economical, as it admits of a greater number of bats being used, so that any bricks broken in transit may be utilized. By using double Flemish bond for walls one brick in thickness, it is easier to obtain a fair face on both sides than with English bond.

Single Flemish bond consists in arranging the bricks as Flemish bond on the face, and English bond as backing. This is often done on the presumption that the strength of the English bond as well as the external appearance of the double Flemish is attained, but this is questionable. It is generally used where more expensive bricks are specified for facing. The thinnest wall where this method can be introduced is 1½ brick thick. Plans of alternate courses are given (Figs. 91 to 99). The front elevations are the same as in double Flemish bond.

English Cross Bond.—A class of English bond. Every other stretching course has a header placed next the quoin stretcher, and the heading course has closers placed in the usual manner (Fig. 100).

Dutch Bond.—In every alternate stretching course a

Fig. 91.

Single Flemish Bond.

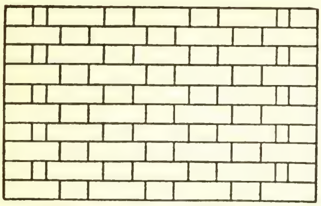


Fig. 92.

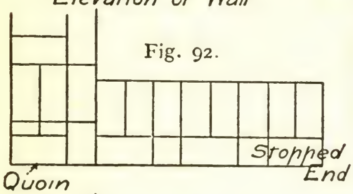


Fig. 93

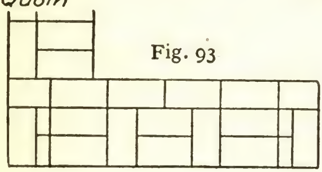


Fig. 94.

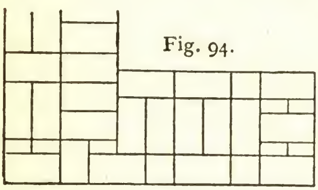


Fig. 95.

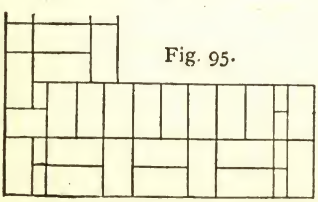


Fig. 96.

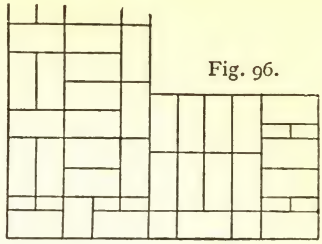


Fig. 97.

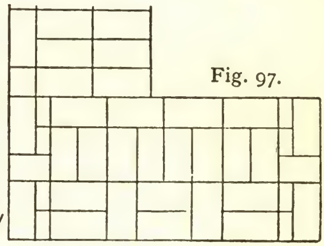


Fig. 98.

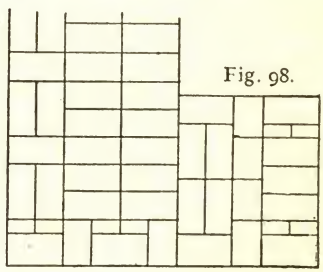
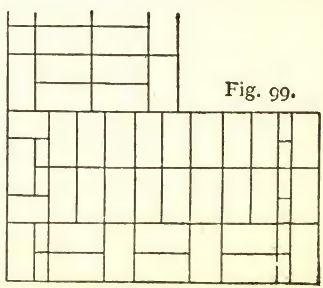


Fig. 99.



Figs. 91–99. Examples of Single Flemish Bond.

header is introduced as the second brick from the quoin; three-quarter bricks are used in the remaining stretching courses at the quoins, and the closers are dispensed with in the heading courses, as shown in Figs. 101 to 105; the longitudinal tie becomes much greater, and the appearance of the elevation is certainly superior to much of the inferior work one is accustomed to see as examples of the modern bricklayer's skill in bonding. Should there be a fracture, it is supposed to throw it more obliquely.

Stretching bond should be used only for walls half brick thick, as for partition walls. All bricks are laid as stretchers upon the face.

Garden or boundary-wall bond, country bond, Scotch bond, are the names given to walls built with three stretchers and one header in same course, constantly recurring, as shown in elevation, Fig. 106. This method is used for walls one brick thick that are seen on both sides, as it is easier to adjust the back face by decreasing the number of headers, the lengths of which usually vary.

Heading bond is used when circular corners have to be turned, as in Figs. 108 and 109. It is evident that stretchers, unless it be upon a large curve, would be too long for this purpose.

In walls built of material in which it is impossible to get a bond, two or three courses of brickwork are frequently introduced to act as a tie or bond; these are termed *lacing courses.* Again, in big arches, consisting of 4½-in. brick wings, lacing courses are sometimes used to give additional strength, as in Fig. 110.

Hoop-iron Bond.—An additional longitudinal tie termed "hoop-iron bond" is often inserted in walls, being usually pieces of hoop-iron 1 in. × $\frac{1}{16}$ in., one

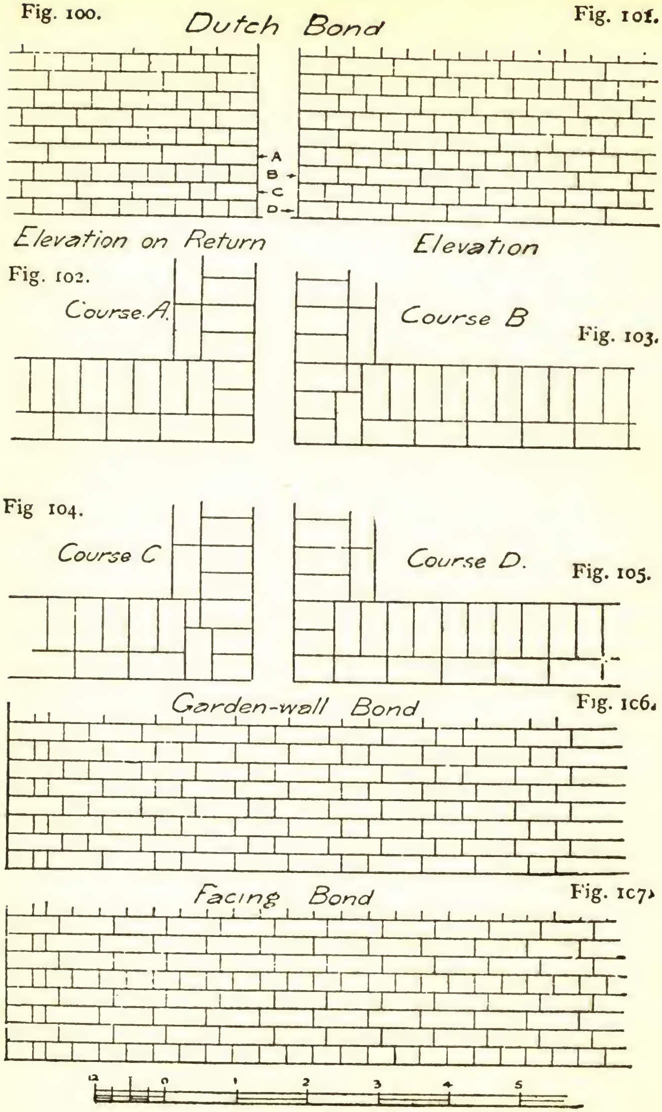


Fig. 100. Fig. 101. Fig. 102. Fig. 103. Fig 104. Fig. 105. Fig. 106. Fig. 107.

Figs. 100–107.

row for every half brick in the thickness; should be carefully tarred and sanded or galvanized before using, to prevent oxidation. It is hooked at all angles and junctions. If bedded in two courses in cement, additional strength is gained; pieces of hoop-iron may be used with advantage where the bond at any part of the wall is defective.

Raking Bonds.—Walls as they increase in thickness increase in transverse strength, but become proportionally weaker in a longitudinal direction, owing to the fact that stretchers are not placed in the interior of a wall.

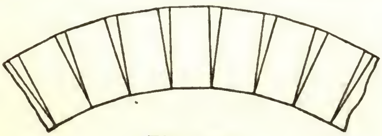


Fig. 108.

This defect is remedied by using raking courses at regular intervals of from four to eight courses in the height of a wall. The joints of bricks laid in this position cannot coincide with the joints of the ordinary course directly above or below, the inclination of the face usually being determined by making the extremities of the diagonal of two, three or more bricks coincide with the backs of the facing bricks. It is not advisable to use one raking course directly above another, as there is always a weakness with the face bricks at the junction of the raking.

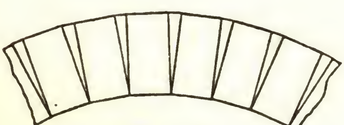


Fig. 109.

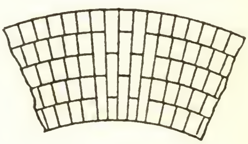


Fig. 110.

Raking bonds are always placed in the stretching

courses in walls of an even number of half bricks in thickness, in order that their influence may extend over a greater area than would be the case if they were placed in the heading courses.

The alternate courses of raking bonds should be laid in different directions, in order to make the tie as perfect as possible.

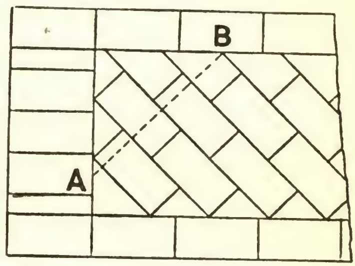


Fig. 111.

There are two varieties of raking bonds, viz., diagonal and herring-bone.

Diagonal Bond.—This is used in the thinner walls, i. e., between two and four bricks in thickness. The operation is as follows: The face bricks are laid; one or more bricks (in the latter case placed end to end) are bedded between the face bricks, so that the opposite corners touch the latter; this determines the angle that the bricks should be laid, the triangular spaces at the ends of the bricks being filled up with small pieces of brick cut to shape, as shown in Fig. 111.

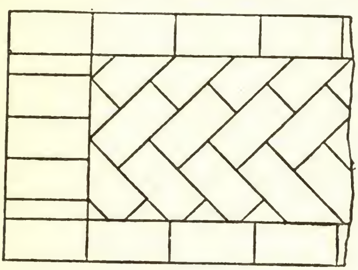


Fig. 112.

Herring-Bone Bond.—The bricks in this method are laid at an angle of 45 degrees, commencing at the center line and working towards the face bricks. Herring-bone bond is used for walls four bricks and upwards in thickness. Fig. 112 shows this method.

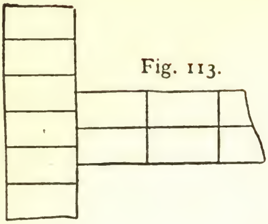


Fig. 113.

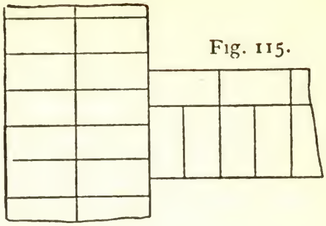


Fig. 115.

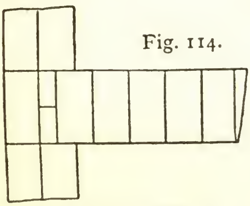


Fig. 114.

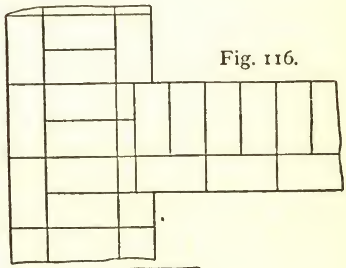


Fig. 116.

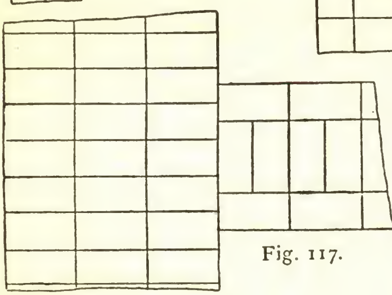


Fig. 117.

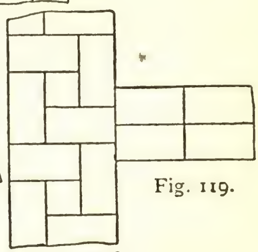


Fig. 119.

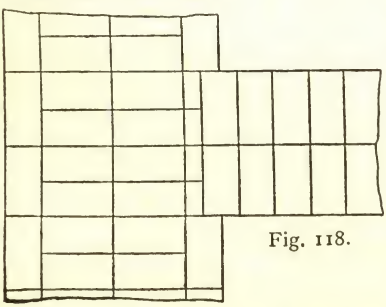


Fig. 118.

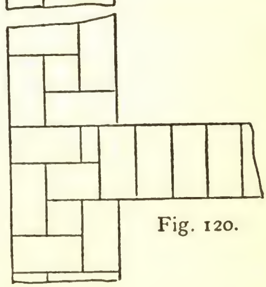


Fig. 120.

Figs. 113–120 Junctions of Cross Walls.

Diagonal and herring-bone patterns are often used to form ornamental panels in the face of walls, and also in floors paved with bricks.

Junction of Cross Walls.—The bond is obtained in cross or party walls abutting against main walls by placing a closer 4½ in. from the face in every alternate course in the main wall, thus leaving a space 2¼ in. deep and of a length equal to the thickness of the cross wall for the reception of the 1¼-in. projection in every other course of the cross wall, as shown in Figs. 113 to 118.

Figs. 119 and 120 illustrate the junction of one-and-a-half brick Flemish bond with one brick English bond.

Reveals.—The vertical sides of window or door openings between the face of wall and window or door frames. The horizontal distance between is the clear span of opening.

Jams are the vertical sides of an opening, and in rebated window or door openings there are the internal jambs and external jambs, the latter being known as the reveals.

Internal jambs are usually covered with plaster, or wood linings.

Figs. 121 to 131 show brick reveals, with rebated jambs in English bond.

Splayed Jambs.—The internal jambs of windows occurring in thick walls are often splayed to obstruct as little light as possible. Figs. 132 to 142 show the method of bonding two alternate courses of a three-brick wall, built in single Flemish bond. In inferior work splayed jambs are often formed by simply constructing a number of square offsets.

Squint Quoins.—External angles other than a right angle in plan are called squint quoins. Such require

Fig. 121.

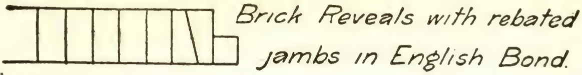


Fig. 122.

Fig. 123.

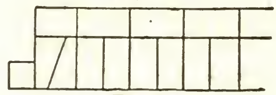


Fig. 125.

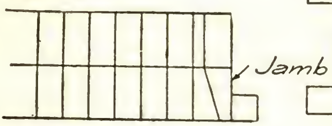


Fig. 124.

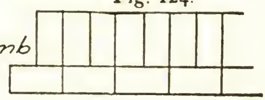


Fig. 126.

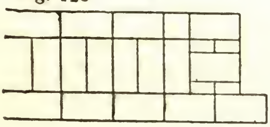


Fig. 127.

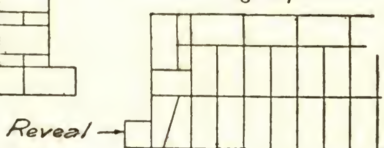


Fig. 129.

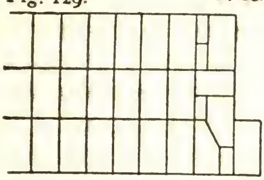


Fig. 128.

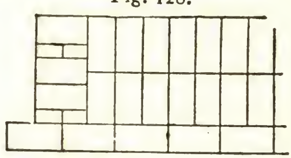
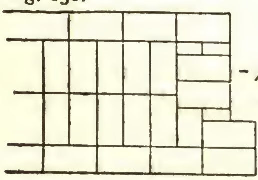


Fig. 130.



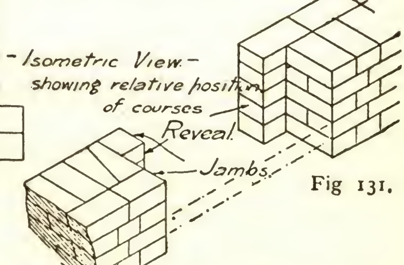
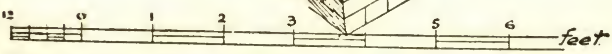


Fig 131.



Figs. 121-131. Brick Reveals with rebated jambs in English Bond.

considerable care in the planning, as different angles require special modifications of the principles of bonding.

Two general rules should be kept in view, viz.: (1) no bird's mouth joint in plan should be employed, except on the face of the work in acute angular quoins, where it is at times absolutely necessary. They would be useful in the interior in some cases, but sufficient care is not usually taken in cutting the re-entering angle where the brick is not exposed to view, the latter generally becoming cracked or broken, as bricks do not lend themselves to be easily cut in this manner. (2) All small pieces should be avoided, the bricks being as nearly as possible whole, and only having sufficient cut off to adapt them to the plan. Closers are not always necessary in obtuse angles; better work is produced where they can be superseded. It is evident that the quoin stretcher can never show its full length on either face. Advantage should therefore be taken, if the angle is not too great, to show three-quarters of a brick at the quoin, as shown in Figs. 137 and 138, thus obviating the necessity of a closer to gain the proper 2¼-in. bond; but in acute angles, the quoin stretcher can always be obtained in its full length, as shown in Figs. 139 and 140.

Figs. 132 to 136 show the method of constructing squint piers, such as would be employed in the angles of bay windows.

Toothing.—The usual method of leaving a brick wall which is to be continued at some future time is to tooth it, which consists in leaving each header projecting 2¼ in. beyond the stretching courses above and below to allow the new work to be bonded to the old as shown in Fig. 144.

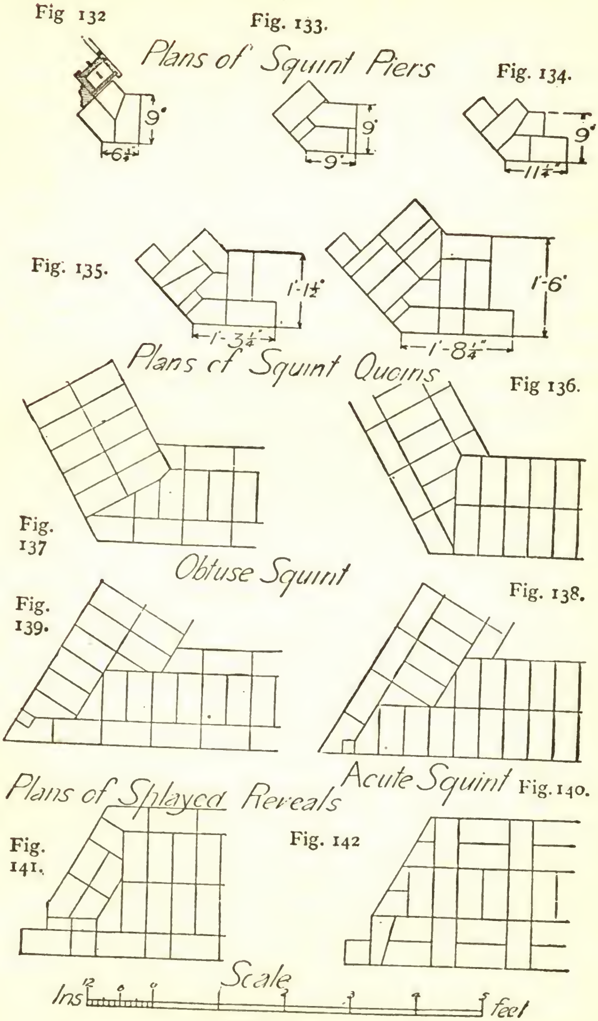


Fig 132
Fig. 133.
Plans of Squint Piers
Fig. 134.
9"
6¼"
9"
9"
9"
11¼"
Fig. 135.
1'-1½"
1'-3¼"
1'-6"
1'-8¼"
Plans of Squint Quoins
Fig 136.
Fig. 137
Obtuse Squint
Fig. 139.
Fig. 138.
Plans of Splayed Reveals
Acute Squint
Fig. 140.
Fig. 141.
Fig. 142
Scale
Ins
12
6
0
1
2
3
4
5
feet

Figs. 132—142.

The usual practice in joining new cross walls to old main walls is to cut out a number of rectangular recesses in the main walls equal in width to the width of the cross wall, three courses in height, and half a brick in depth; a space of three courses being left between the sinkings (as shown in Fig. 143); the new cross wall is then bonded into the recesses with cement mortar to avoid any settlement. It is necessary that the sinking should not be less than 9 in. apart, as in the cutting the portion between is likely to become shaken and cracked.

Racking.—Racking is the term applied to the method of arranging the edge of a brick wall, part of which is unavoidably delayed while the remainder is carried up. The unfinished edge must not be built vertically or simply toothed, but should be set back 2¼ in. at each course, to reduce the possibility and the unsightliness of defects caused by any settlement that may take place in the most recently built portion of the wall.

Also where new walls are erected the usual method of procedure is to build what is technically termed a corner—that is, the angles or the extremities of the walls—to a height of two or three feet, the angle bricks being carefully plumbed on both faces. The base of the corner is extended along the wall, and is racked back as the work is carried up, as shown in Fig. 145. The intermediate portion of the wall is then built between the two corners, the bricks in the courses being kept level and straight by building their upper edges to a line strained between the two corners.

Leveling of Brickwork.—In bedding bricks, great care should be taken to keep all courses perfectly level. To do this, the footings and the starting course should be carefully leveled through, using a level at

Fig. 143.

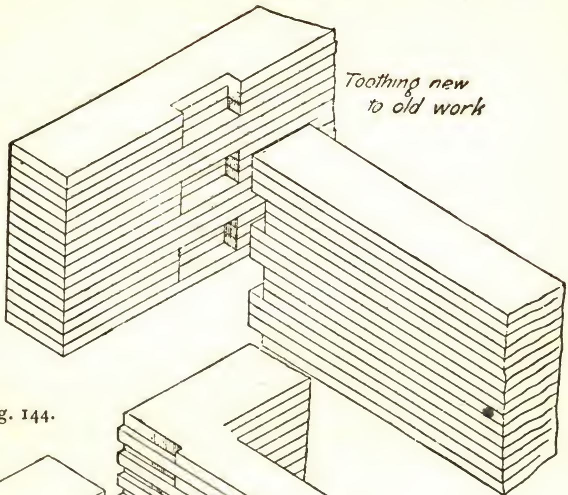


Fig. 144.

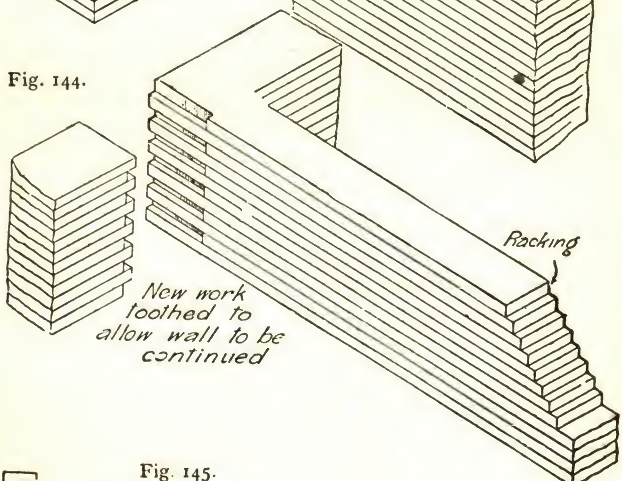
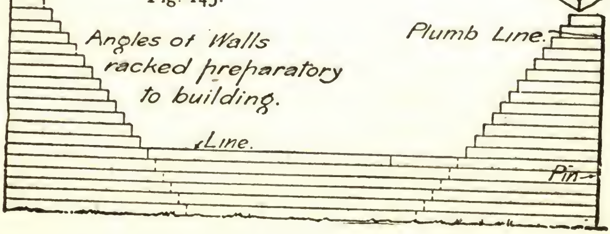


Fig. 145.



least 10 ft. in length, commencing at one end and leveling towards the other, and taking care to reverse the level each time at each forward step, and completing the length to be leveled in an even number of steps. A piece of slate or iron is left projecting from the lowest course, and from this all other courses at the corners can be leveled by using the gauged rod, which is usually about 10 ft. in length, with the courses marked on it. The work should then be again tested by the level, and the operation repeated.

Joints.—Bricks and stones are bedded with mortar for two purposes, viz., to cause the bricks to adhere to each other, and to distribute the pressure uniformly over the whole bed where the beds of the bricks or stones are irregular. Great care should be taken that both the bed and side joints are thoroughly flushed, or filled up with mortar. This is done in three ways: 1, by the trowel; 2, by larrying; 3, by grouting. The first method is that usually adopted in thin walls. The second, larrying, is largely adopted in thick walls. The face bricks are first laid; the mortar, in a semi-fluid condition, is then poured into the space between the face bricks; the bricks are then pushed rapidly horizontally for a short distance into their position; a certain amount of the mortar is thus displaced; this rises in the side joints, and completely fills all the interstices; should the mortar not rise to the top of the joints, the vacant spaces are filled up when the next course is larried. (3) Grouting is an operation used in brickwork, generally for gauged arches and similar work, where fine joints are required; it consists in mixing the mortar to a fluid condition, of about the consistency of cream, this being poured into the joints of the work after the latter has been placed in position.

Joints on Face.—The joints on the face of work are finished in a variety of ways, as shown in Figs. 146, A to L, to increase the effect, and to resist the weather; they may be finished as the work proceeds, or as the scaffold is taken down on the completion of the building; the former is the stronger and more durable, the latter is cleaner and has a better appearance, and is rendered necessary when the work has been built during frosty weather; where the latter method is employed, the joints should be raked out for at least ½ in. in depth as the work proceeds. The joints in new work should be clean, sharp and regular; but no fancy pointing is permissible. Fig. 146, A to L, shows the forms of joints applied to brickwork.

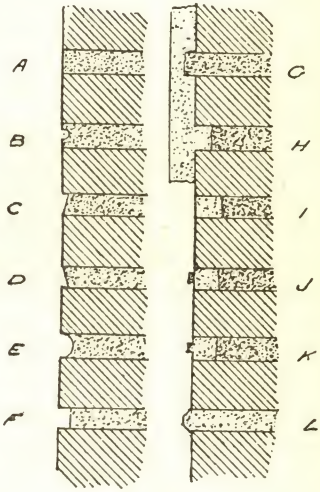


Fig. 146 *a* to *l*.

Flat or Flush Joints.—This is formed (as shown in Fig. 146, A) as the work proceeds by pressing with the trowel the wet mortar that protrudes beyond the face, flat and flush with the wall.

Flat Joint Jointed.—This is formed similarly to the above (as shown in Fig. 146, B), but has, in addition to the previous joint, a semicircular groove run along the center of each joint, with a jointing tool and straight-edge. This has the effect of making the mortar more dense.

Struck Joints.—This is formed by pressing with the trowel the mortar along the upper edge of the joint slightly below the surface, as shown in Fig. 146, C. This is a good joint, as the upper edge of the mortar is protected, and any water is thrown off with facility; its appearance is good, as it presents a sharp shadow at every horizontal joint, and forms the method of finishing new work; it is sometimes called a weather-struck joint. The mortar is often ignorantly struck back on the lower edge, as shown in Fig. 146, D, under the impression that the appearance is enhanced thereby, the idea being that a sharp line is presented on the upper edge of the bricks, but as no shadow is formed the effect is lost at a few feet above the eye; a ledge is formed on which the water lodges, which freezes in the winter, and rapidly destroys the upper edges of the bricks and the joint.

Keyed Joint, as shown in Fig. 146, E, is formed by drawing a jointing tool with a curved edge, the same width as the joint, along the latter; it has the effect of making the mortar dense at this part, and improves the appearance by making the joints distinct. It is not much used.

Keyed joints of the form shown in Figs. 146, G and H, are employed where the wall is to be rendered. In the first case, the mortar in the joints is left protruding; in the second, it is raked out.

Recessed Joint.—This is used to obtain a pleasing and deep shadow, but care must be taken that the bricks are hard and unlikely to be damaged by the weather. It is the joint employed in many of our best buildings. Fig. 146, F, gives this joint.

Pointing Old Works.—This operation consists in raking out the decayed mortar from the joints to a depth

of at least ¾ in. and in filling the same with cement, or some hard-setting mortar, as shown in Fig. 146, I. The joints may be finished in any of the methods stated, or by one of the two methods known as tuck and bastard tuck pointing, which are fancy forms adopted by bricklayers to increase the effect by forming sharply defined joints.

Tuck pointing, as shown in Fig. 146, J, consists in filling up the raked-out joints flush with a stopping of cement or some hard mortar. The joints in this condition generally appear very wide, owing to the edges of the bricks being ragged, this being due to the frost or to the clumsy method in which the joints have been raked. The whole front, joints included, is then colored with a compound of copperas and a pigment of the color required, or the front is rubbed with a piece of soft brick till the bricks and the joints are of one color. While lime putty is pressed on to the joints in straight lines, with a jointer worked on a beveled edge straightedge, and before the latter is removed, the edges are trimmed with a tool called a Frenchman, which usually consists of an ordinary table knife with the end of the blade turned up at right angles to the remainder. The edge of the knife cuts the putty, and the turned-up end drags off the superfluous stuff, leaving a white joint ¼-in. in width and $\frac{1}{16}$-in. in thickness on the face of the work. This is not the best method of pointing if the bricks are sound and their edges sharp and regular; but if the edges are broken, the joints, when stopped, appear very wide and irregular, and are thought by some not to look well if the above process were not adopted. This method should never be permitted.

Bastard Tuck Pointing is the name given when a

ridge ¼ in. to ⅜ in. is formed on and off the stopping itself, as shown in Fig. 146, K.

Masons' V Joint, Fig. 146, L, shows the usual joint used for masons' work.

CHIMNEY BREASTS, FLUES, ETC.

These have to be formed according to the design of the house; but in most cases, for the sake of economy in space, etc., the fireplaces are built, one over the other, from floor to floor, and frequently in party walls, the latter being the wall which divides house from house. The openings will differ in size, according to the range or grate used. For example, a full sized range would require an opening 4 ft. wide and 1 ft. 10½ in. deep; the extra depth, beyond what is required for the flue, being lost when the flue is in position by arranging a set-off in the breast to form a mantel-shelf. For an ordinary register stove the opening would be 3 ft. wide by 12 in. deep, and so on, and, unless provision be made by a breast breaking out upon the outside of a building, a projection or breast must be formed inside the rooms to receive the stoves and provide for the flues. The back of the fireplace should not be less than 9 in. in thickness; therefore the projection of the breast depends upon the thickness of the main wall and style of stove to be used. That is to say, if the depth of the fireplace be 1 ft. 1½ in., then in an 18-in. wall with a 9-in. back to fireplace, the breast would project 4½ in ; in a 14-in. wall, 9 in., etc.

It is most desirable to have as much bend as possible in flues; not to have the flues larger than is necessary (a kitchen flue should be 14 × 9 in., an ordinary living room 9 × 9 in.); to gather in quickly above the arch,

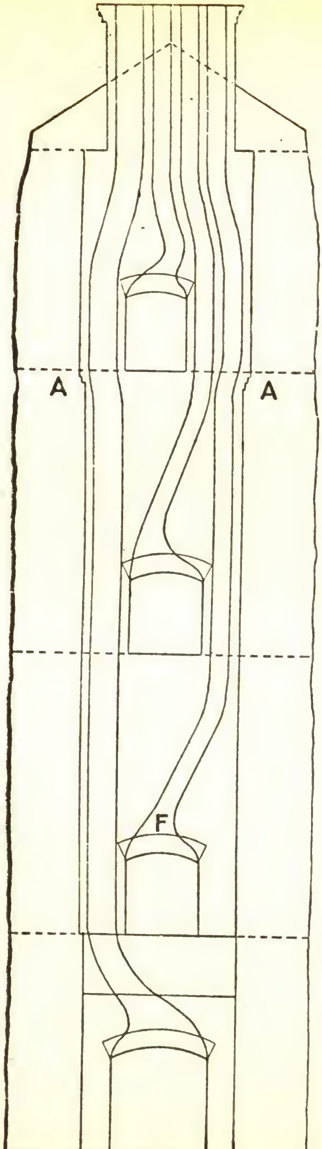


Fig. 147.

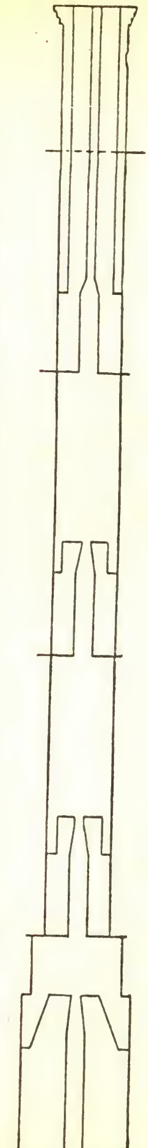


Fig. 148.

though not so quickly as to form a nearly flat surface immediately above the fire; and to have perfectly easy bends, with no abrupt angles. For a flue to successfully do its work, smoke should be treated as though it were water. Sharp turns and breaks interrupt the

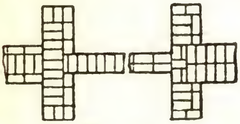


Fig. 149.

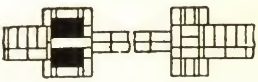


Fig. 150.

easy flow of the smoke, causing it to eddy round, choke the flue, and return again to the room. The inside should be smoothly rendered with pargeting, i.e., cowdung and lime, in the proportion of 3 to 1.

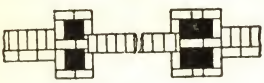


Fig. 151.

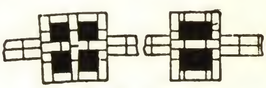


Fig. 152.

This makes a smooth surface, is tough and is supposed to prevent the smoke stains and heat from coming through the wall. Ordinary mortar, however, is now more often used than pargeting. Fig. 147 is the sectional elevation of fireplaces over each other, as far as is possible, in a double-breasted wall; Fig. 148 being a cross-section taken through the double breast; Figs. 149, 150, 151 and 152 are plans of the same on the basement, ground, first and second floors; while Fig. 153 is a plan through the stack.

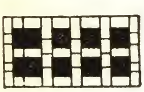


Fig. 153.

Chimneys and flues may be constructed at any angle, on condition that any flue inclined at an angle less than 45 degrees is provided with suitable soot doors.

Mistakes are often made in constructing flues

through not carrying them fast enough to the right or left, as the case may be, so as to prepare for the fireplace above; then, when the mistake is discovered, they are carried over quickly, and a flat surface is formed, resulting in a faulty flue. To obviate this, an easy calculation should be made as soon as the flue is gathered over and brought into position above the fireplace. Taking Fig. 147 as an instance, the flue being in position 2 in. above the arch, measure the height to the fireplace above, and the distance the flue has to be taken to the right or the left; or, in other words, ascertain how many inches it has to be taken laterally to the foot vertically. In the case in point, F is the flue in position in the middle of a 6-ft. 4-in. breast. The distance to the fireplace above is 6 ft. and the 9-in. flue has to be carried to the right, allowing 4½ in. outside work. Then it is evident that the left side of the flue has to be carried a distance of 2 ft. in 6 in. or 24 in. in twenty-four courses, to get into position; that is to say, the flue must recede on the under side, and sail over on the upper, 1 in. in every course.

Fireplace Jambs.—When starting the fireplace in the basement, the jambs on each side will be solid, and are usually 14 in. on the face by the depth as already described. The flue, being taken either to the right or to the left, will appear upon the next floor as a jamb 18 in. on the face. This allows 4½ in. outside work, and a 9-in. flue. If, however, the flue should be 14 × 9 in., then the jamb will be 23 in. on the face.

As already stated, fireplaces vary from 2 ft. 6 in. to 4 ft. in width, according to the stove to be used; and they will also vary in height, that for a kitchen being 4 ft., and for an ordinary register 3 ft. high. When

the proper height is attained, an iron chimney bar is placed in position. This slightly curved bar (Fig. 154) is 3 in. wide, ¾ in. thick, and rests 4½ in. each end upon the jambs, the ends also being split and turned half up and half down into the brickwork. An arch of two or three half-brick rings is then carried over upon the chimney bar, and the work continued above it (Fig. 155). Instead of the iron bar, lintels of coke breeze and cement, or an arch turned on a temporary turning piece, is now frequently used.

Fig. 154.

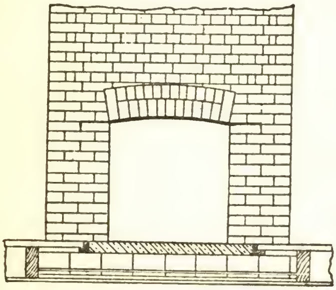


Fig. 155.

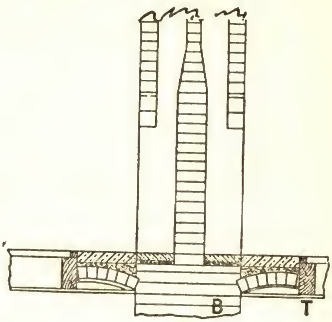


Fig. 156.

Mode of Carrying the Hearth.—The hearth should be at least 18 in. wide, and extend beyond the fireplace opening 6 in. each way. There are several methods of supporting the hearth, but the most usual is by means of the trimmer arch. Turning pieces are fixed in between and at right angles to the trimmer T and the breast B (Fig. 156), covered with thin lagging, seen in section in the last named figure; the arch, consisting of rows of stretchers on edge and parallel to the breast, is then carried over and properly keyed in (see Fig. 157, which is a horizontal section taken

through the fireplace, and showing the trimmer arch on plan). Another good system is that of tee-irons with the table turned downwards, fixed in between the trimmer and breast, sheeted with temporary boarding underneath, and filled in with concrete. Fig. 158 is a longitudinal section taken through such a hearth. Or the tee-irons may be fixed as already described, but kept such a distance apart as to allow a plain tile to be placed in between two adjacent webs lengthwise. Three courses of these tiles should then be laid and properly bonded in Portland cement and sand. Fig. 159 is a cross-section illustrating the latter system. In each system the surfaces are brought to with concrete to within ½ in. of the under side of the hearth, the ½ in. being allowed for bedding. The back hearth, when there has been no breast below, will be treated in the same way as the front, but in all other cases will be bedded on the brickwork.

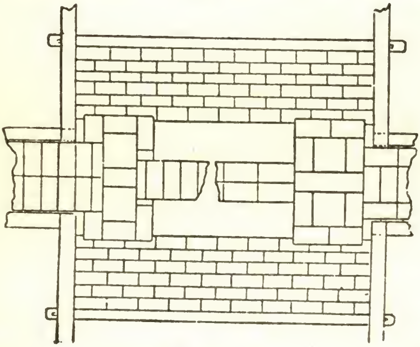


Fig. 157.

Every flue should be complete in itself, for if opening be left in the 4½-in. walls—or withes, as they are termed—which part flue from flue, the smoke will enter the flue not in use, and a down current will take it into the room.

Coring-holes 12 × 9 in. should be left, and temporary boards fixed in each flue and upon each floor, for the

purpose of clearing out the rubbish that may fall down the flue during the building.

Corbeling.—If it should be necessary to increase the width of the breast, this may be done by corbeling the brickwork between the floor and the ceiling. By sailing over 1½ in. per course on each side for three courses, the breast may be increased 9 in. (Fig. 147, A A). When anything beyond this is required, then stone corbels should be used. If the fireplace jambs are not carried up from the basement upon solid foundations, but grow out from the party wall, as it were, by means of corbeling, then the breast may project the thickness of the wall upon which it depends.

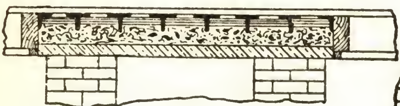


Fig. 158.

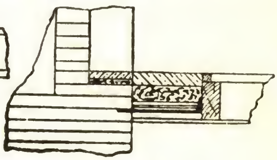


Fig. 159.

Hard stone corbels are really more reliable than brick corbeling for this purpose.

When the chimney breast has taken in all the fireplaces and flues required, and appears above the topmost ceiling, the flues are brought into the position in which it is desired they shall be seen when above the roof. This, when out of sight, is done by dropping off the superfluous brickwork in offsets. But when the breast appears as a projection upon the outside of the building, then one method of reducing it is that shown in Fig. 160.

Bond in Chimney Stacks.—Though it is far preferable to have 9-in. outside work to chimney stacks, to keep out both the rain and the cold, which retard the even

flow of the smoke, yet it is more often that the outside work is 4½ in. only. In bonding stacks, the desired end to be kept in view is that the withes or partings shall be tied in, so as to strengthen what might otherwise be a very weak construction. When the flues are surrounded with 9-in. work, either English or Flemish bond may be adopted. Figs. 161 and 162 are plans of alternate courses of the first, and Figs. 163 and 164 of the latter. It is with 4½-in. work outside that the great difficulty occurs, and up to the present a broken kind of bond, called chimney bond, in which the withes

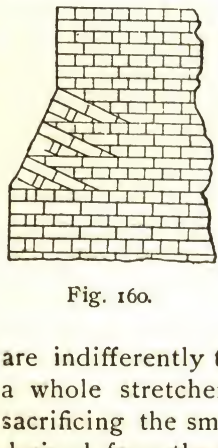


Fig. 160.

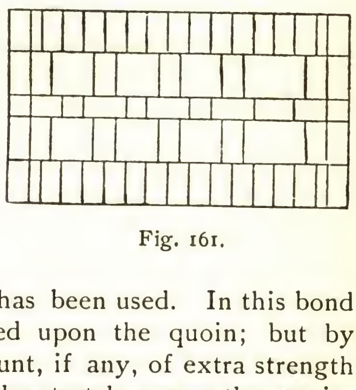


Fig. 161.

are indifferently tied in, has been used. In this bond a whole stretcher is used upon the quoin; but by sacrificing the small amount, if any, of extra strength derived from the use of the stretcher upon the quoin, and substituting a three-quarter bat in the stretching course, instead of using a closer in the heading course, the work may be built either in English or Flemish, and a perfect tie and bond be secured. (See Figs. 110 and 111 for plans of alternate courses of English, and Figs. 112 and 113 for the same in Flemish bond.)

According to some strict building acts, chimney shaft or smoke flue shall be carried up to a height of

not less than 3 ft. above the roof, flat, or gutter adjoining thereto, measured at the highest point in the line of junction with such roof, flat or gutter. And the highest six courses of every chimney stack or shaft shall be built in cement.

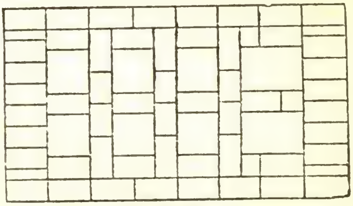


Fig. 162.

Setting Ranges.—Built in and close- fire ranges are many and varied in description; but there are general rules for guidance in setting them that are applicable to nearly all. Double-oven ranges are of course the largest, and the American or self-setting range the smallest. With the latter but little skill is required, while the setting of the former is somewhat difficult.

To proceed to set a range, the first necessary operations are to properly level in a hearth or course of brickwork to take the oven cases; to temporarily place the range in position so as to mark the flues, etc., and to build in beneath each oven case sufficient brickwork to allow a 2-in. cavity below the oven. It will be found that the heat from the furnace traverses the top of the oven, and is then induced to descend on the outside or end of the range to the front of the check, which is a piece of sheet iron fixed diagonally on the bottom of the oven, and coming from the back extreme corner to within 4 in. of the front of the soot door in

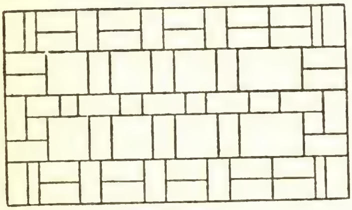


Fig. 163.

the face of the bottom of the range, and centrally beneath the oven door. The flue at the end should cover as much surface as possible, and should not exceed 2 in. wide by the length of the side of the oven, the object being to keep the heated air and gas as close to the oven and over as wide a surface as possible.

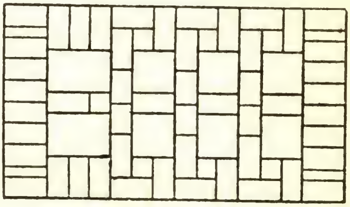


Fig. 164.

It has been described how the flue is formed to the front of the check; it is then allowed to go to the center of the back at the bottom of the oven, and from that point is taken up in a flue usually 9 in. or 10 in. wide and 3 in. to 4 in. deep, which ascends vertically to the damper, which is placed at the top of the back coving. The covings are sheets of paneled cast iron that encase the recess above the top plate, the covings, in their turn, being

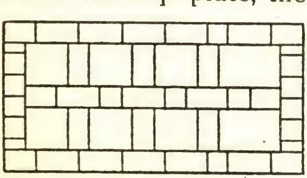


Fig. 165.

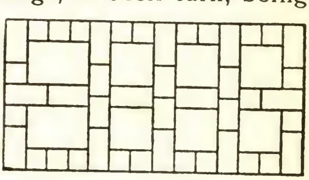


Fig. 166.

covered with a top plate. They are usually fitted with a plate rack, and should be bedded with mortar against the insides of the jambs and the brickwork at the back which is formed between the flues.

The boiler is set on a benching of fire-brick built at the back of the ash pan and is usually arranged with a flue from the bottom of the furnace to the back of the

range, and a vertical flue formed in a similar manner to the oven flue up to a damper placed at the top of the back coving. The boiler, which should be of wrought iron, is drilled and tapped for the connecting of the hot-water circulation.

These are general methods, but special kitcheners often require different treatment. In every case there should be no sharp turns in the flues, and the top flues should be carried above the dampers in the direction of the chimney flue above.

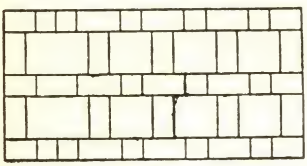


Fig. 167.

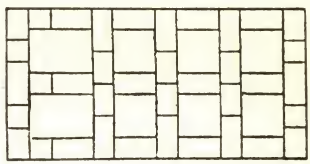


Fig. 168.

Register, Mantel Register, and Interior Stoves.—The main object in fixing these is to fill up with brickwork the space which, in the fireplace opening, is not occupied by the stove or flue. In some cases the register is placed in position, and set by filling in the brickwork through the register flap which forms the entrance to the flue for the smoke. These are often insufficiently filled up, thereby leaving a large cold-air space at the top, which causes the smoke to be checked and sent back into the room, instead of pursuing its proper course up the flue.

For interior grates with fire-lump backs, the shape of the back of the lump should be marked out upon the hearth, and brickwork built up to the shape, allowing for a mortar bed at the back of the lump. Here, again, it is important that the opening should be filled up as much as possible, leaving only the size of the flue.

ARCHES AND GAUGED WORK*

Gauged work consists in rubbing and cutting to any required shape specially made bricks, or "rubbers," as they are technically termed.

This class of work is usually done in what is called a cutting shed, provided with a bench about 2 ft. 3 in. high and 2 ft. 6 in. wide.

The tools and appliances required are a rubbing stone, circular in shape, and 14 in. in diameter; a bow saw fitted with twisted annealed wire No. 18 gauge, parallel file 16 in. long, small tin scribing saw, square, bevel, straight pieces of gas barrel for hollows in mouldings, etc., bedding slate to try the work for accuracy, straight-edge, compass, setting trowel, putty box (Fig. 169), boaster, club hammer, and scotch (the three latter for axed work), reducing boxes for thickness (Fig. 170), and for length (Fig. 171), moulding boxes (Fig. 172), boxes with radial sides for obtaining the wedge-shaped voussoir according to the template (Fig. 172½), a setting-out board about 6 × 5 ft. and lining paper 2 ft. 6 in. wide, etc.

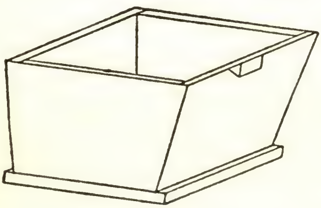


Fig. 169.

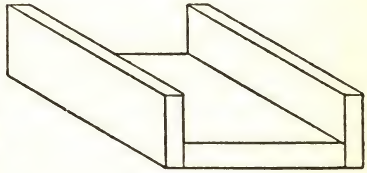


Fig. 170.

The most elementary kind of gauged work is that

*This department is largely taken from H. W. Richards' work on "Brick-laying and Brick-cutting."

which is known as plain ashlar, consisting of heading and stretching courses for plain facing. The operations are as follows: first bed the brick, i.e., place the brick with the letter or hollow side on the rubbing stone; then, holding the brick with both hands, rub it upon the stone, giving it a circular motion from right to left, and trying it occasionally with a straight-edge till the bed of the brick has become a perfect plane.

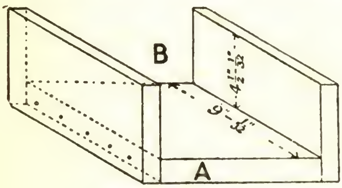


Fig. 171.

Next, with the rubbed bed turned from the body, place the side or face of the brick upon the stone, and rub as before, at the same time endeavoring to make the side square with the bed, testing it by application of the square, stock to the side, and the blade to the bed of the brick. Then serve the head in the same way, making it square with both bed and face. After these operations are perfect, the brick has to be reduced to thickness; this is done by placing it on its bed in a reducing box (Fig. 170), the measurement of the inside depth of which is $\frac{1}{16}$-in. under 3 in., sawing off the superfluous material and finishing with a file.

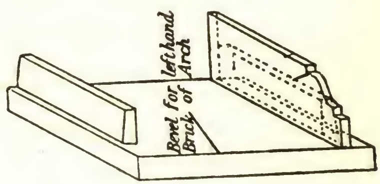


Fig. 172.

If for a stretcher, next place the brick face downwards in a 9-in. lengthening box (Fig. 171), making the square end to coincide with the front edge A of the box, and saw off to length, finishing with a file at

the back edge B. The cut stretcher will be 9 in. less $\frac{1}{32}$ in. in length.

In preparing long headers, the brick would have to be placed in the same box, face downwards, but the saw and file would be used along the top edge of the box, thus making the header 4½ in. less $\frac{1}{32}$ in. in width. If for bat headers, then the squared end is placed downwards in the box, and saw and file used along the top edge again.

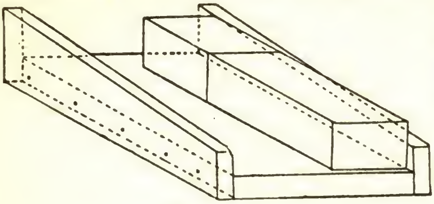


Fig. 172½.

Arches.—These may be plain, axed or gauged.

In plain or rough arches the bricks are not cut at all; the joints alone give the radiation, and the arch is usually made up of rings.

The Relieving Arch.—The relieving or discharging arch (Fig. 173), as its name implies, is used for the purpose of relieving the weight from any portion of the building which is too weak to bear it, and discharging or transmitting it to piers, etc., specially prepared to receive the load. They are sometimes used in the face of build-

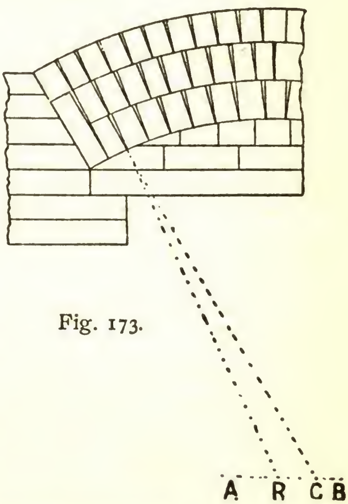


Fig. 173.

ings, when they are also treated as ornamental features.

The most frequent use for the relieving arch is inside the building, over door and window openings. The opening is first bridged by the lintel, which should rest not less than 4½ in. upon the jambs each side of the opening; next a brick core is built throughout the entire length of the lintel, to serve as a turning piece for the arch; the curve being obtained by means of a curved mould having the same rise it is intended to give the arch. This is applied to the face of the core; the bricks are marked, and then cut to shape. A skewback, which should radiate from the striking point, is built at each end of the lintel; and the arch, consisting of 4½-in. brick rings, but starting with a stretcher at each end upon the skewback, is then turned over the core. When a flat rise only is given, the brick core is done away with, and the curve is worked upon the lintel.

It must not be forgotten that the lintel is in length the exact span of the arch; that the object of the lintel is for the purpose of fixing the joinery; that the core acts only as a turning piece for the arch, and to fill up the space between this and the lintel; and that neither of them influences the strength of the discharging arch in any way. Should a fire occur, the lintel would burn and the core fall, but the arch ought to remain intact. The method of striking out the arch will be the same as that given for the segment.

When arranging the rings, those starting from the top and working downwards alternately should always have a key-brick; the other rings will key in with a joint. As already stated, in this as in all other rough arches, the bricks themselves are square, and the radiation is obtained by means of the joint. The

mode of drawing the radial joint is as follows: prick over the 3-in. courses and fill in the face from the radial point R, as in the semi-arch. Through the radial point, and parallel with the lintel, draw an indefinite line A B; make one of the courses or bricks of the arch parallel, by keeping the *top* equal to the *bottom* of the brick; produce the line which does this so that it cuts the line A B, in C, then C will be the point by means of which a line drawn from it through the soffit end of the face joint of each course will give the radial joint. This method must be followed each side of the arch.

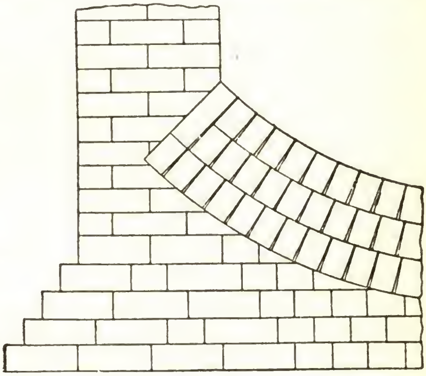


Fig. 174.

The Invert Arch.—It often occurs that the principal loads in buildings, such as girders carrying the floors, etc., are concentrated upon certain points, as piers, for instance, which are usually strengthened to receive them. Should there be openings upon each or one side only of the pier, it is very evident that the weight of the pier and its load would be taken vertically downward to one part of the footings only, little able, perhaps, to bear it.

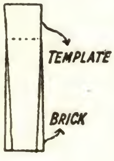


Fig. 174½.

To relieve the special part of some of the weight, by spreading it over a larger area of footings, invert arches are used, as in Fig. 174. Here

some of the weight is taken from the pier A and its fellow, and transmitted, by the invert arch, to the footings in between them. It will be noticed that the lines from the radial point to the skewbacks form an angle of 45 degrees, this being found to be the best angle to receive the weight.

Chimney breasts in basement stories are often treated in this manner.

Egg Shaped Sewer (Fig. 175).—This sewer, as its name indicates, is shaped like an egg, with the smaller end downwards, this shape being found the best adapted for the varied charge of sewage. It matters little whether it be during a time of storm water, or during a dry season, when there is but small quantity of sewage, there is always a sufficient depth of matter to ensure a perfect flow. The sewer may consist of two or three 4½-in. rings of brickwork, with a terra cotta or hard-brick invert; bedded in concrete. The mode

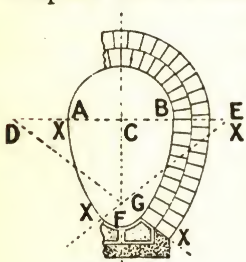


Fig. 175.

of setting it out is as follows: Let AB be the diameter of the head, or crown, then CB will be the radius, and C the radial point; measuring out from the center C to the left and right of A and B, a distance equal to AB, will give the radial points D and E, from which the curves of the sides may be described; then, for the invert, draw from the point C at right angles to AB a line CF equal to AB. By dividing CF into four parts, the radial point G will be found. The termination of the sides x, x, and the beginning of the invert is determined by lines passing from D and E through G. The 4½-in. rings will be arranged

as in the relieving arch, the outer rings having the key bricks, one at the crown, the line FC passing through the center; and what might be termed two keys, one on each side, the line DE passing through their centers; the next ring towards the inside having straight joints at these points; the next inner ring, keys, and so on.

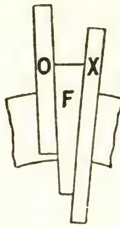


Fig. 176½.

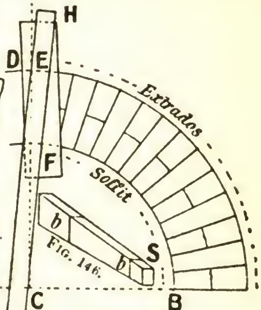


Fig. 176.

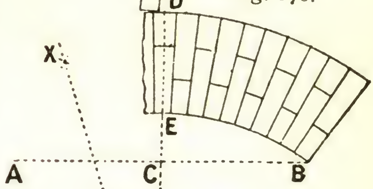


Fig. 177½.

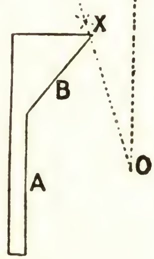


Fig. 177.

Axed Arches.—Axed arches are really roughly cut gauged arches with a $\frac{3}{16}$-in. mortar, instead of a $\frac{1}{32}$-in. putty joint. Therefore, the mode of obtaining the template and the system adopted for gauged arches generally, applies equally well to axed ones; the only difference being that when the bricks are hard, the brick will have to be scribed each side to the template and across the soffit with a tin scribing saw, and cut off to the scribed lines with a boaster (sometimes called bolster) and club hammer upon the banker, and the remaining

material between the scribed and boastered lines neatly axed off with a scotch (sometimes termed scutch).

In arches in which the end or soffit may not be cut to a bevel, such as glazed bricks, etc., the mode of applying the template to the face of the brick is somewhat different. It would simplify the matter, perhaps, if, after the template was obtained, as described, the bottom of the template were to be cut off to the cutting mark, and made to fit the soffit line of the drawing of the arch and then applied to the face of the brick, the brick and template both being on end, and both the bed and back of the brick cut off to the template. That is to say, both edges of the template would be cutting edges (Fig. 174½, which shows the template in position for cutting the brick).

Gauged Arches.—Throughout this work one principle is adopted for setting out and obtaining the templates for all gauged arches, and by careful attention to the instructions given, all practical men should be able to gain a perfect mastery of the subject. Whenever the compass is mentioned, it will be understood that in full-size work the radius rod would be used, and although, when describing the construction, the whole of the arch is alluded to, a half only is drawn, as would be the case when setting out in practice.

The Semicircular Arch.—This arch is known always as the semi (Fig. 176), the opening here being 3 ft., the face 9 in., and the soffit 4½ in.

Construction, etc.: Draw an indefinite base line; upon and perpendicular to it erect a center line; upon the base line set out the opening AB, half each side of the center line; then with the point of the compass at the center C, and the pencil at B, describe the

larger half of the soffit, or intrados, and with the point still at C, but the pencil extended 9 in. beyond B, describe the outer line or extrados. In most rubber bricks the brick and joint together will hold out or measure 3 in. Therefore take a distance of 3 in. in the dividers, and starting with half the distance each side of the center line on the extrados, prick over till the courses come home exactly to the springing line, increasing or decreasing the distance taken in the dividers, i.e., making it slightly over or under 3 in.; but always taking care that the first pricking, or key-prick, shall be equally divided half each side of the center line. Call these first two prickings D and E. From the center C, through D and E, draw the approximate key, but producing the line through E to H. This approximate key will also be the shape of the trial template.

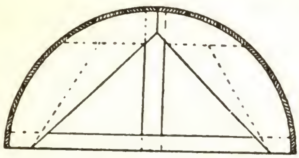


Fig. 178.

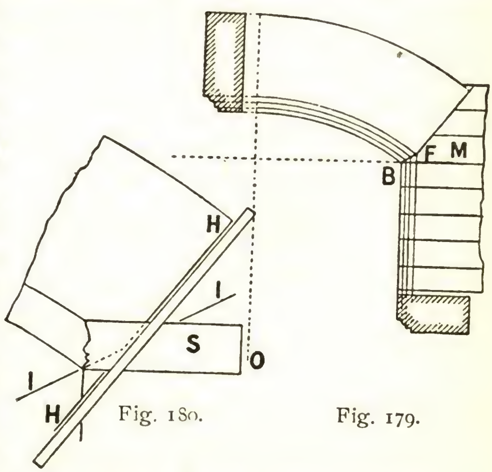


Fig. 180.

Fig. 179.

To obtain the template the following pieces are necessary: two small straight-edges $16 \times 2 \times \frac{1}{2}$ in., and also a piece of board $14 \times 3\frac{1}{2} \times \frac{1}{2}$ in., with both sides

planed and one edge shot square and true. Place the latter, which may be termed F, Fig. 176, with the shot edge against the line radiating from C to D, and with a long straight-edge having the end of one edge against the radial point C, and the other end coinciding with the produced line H, and laying over F, mark the latter the shape required. Having cut and shot the template to the line drawn upon it and square with the face (when it will appear as F, Fig. 176½), proceed to traverse it; i.e., see that in pricking over there are fourteen courses in half the arch, including the key; ascertain whether fourteen such templates

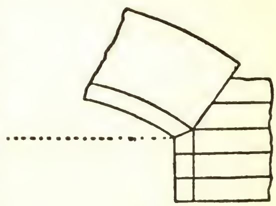


Fig. 181.

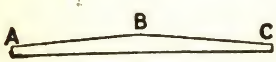


Fig. 182.

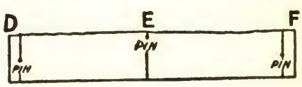


Fig. 183.

will exactly fill half the arch, starting with the key and terminating with its edge upon the springing line. The way to traverse the template is as follows: Place the template upon the approximate key, taking care that it exactly fills it; draw a pencil line, which will be known as the filling-in mark, across the left-hand edge of the template and immediately over the soffit line. Next place the two straight-edges O and X one upon each side of and tight up to the template, always keeping O a

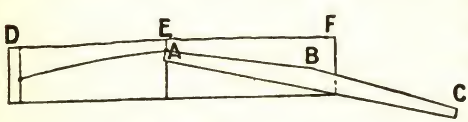


Fig. 184.

little above the filling-in mark, Fig. 176½. Keep X firmly in its place, remove the template, slide O against X, remove X, place the template against, with the filling-in mark on the soffit line; place X against it, remove the template, slide O against X; and repeating this movement till the right-hand edge of the template comes out to the springing line. Should the template at the last turn be parallel to the springing line, but not quite home to it, bring the template down a little by placing the filling-in mark higher up. The top may come over the springing line, and the bottom reach or not quite reach home; then a shaving or two must be taken off the top, or if the bottom comes over, then a few shavings off this. Each time it becomes necessary to alter the filling-in mark or the template itself, it will be necessary to traverse again, taking care always, at the start, that the template is equally divided, half each side of the center line. When the template has been obtained, line in the joints of the arch with it. The next important matter is to allow for joint. This is done by placing the edge of the template against the radial line CD, backing it up with the straight-edge O kept firmly in position; then, by sliding the template up against the latter, it will recede from the radial line CE. If for axed work the template may be worked up till it leaves the radial line CE by $\frac{3}{16}$ in.; if for gauged work, by $\frac{1}{32}$ in.; then, in a similar way to that in which it was marked for filling in, scribe for cutting mark immediately over the soffit line, Fig. 176, S. When for gauged work, to prove that the amount allowed for the joint is correct, traverse the template again, with the *cutting* mark on the soffit line, for four courses, when, if it leaves the fourth line by ⅛ in., it may be taken

as correct. In this arch the lengths of all the courses are alike, and may be taken on the edge of the template, bearing the cutting work; this edge being termed the cutting side of the template, and the other the bed, coinciding in this respect with the arch-brick itself. Place the bed of the template against the radial E, with the cutting mark upon the soffit line, then on the cutting side make a mark on the edge immediately over the extrados (these marks should always be squared across). While the template is in this position, the bottom and top bevels B may also be obtained, by making similar squared lines on the bed of the template, and then connecting these on the face, as in Fig. 177½.

In using the template, the soffit bevel will be taken off by placing the blade of the bevel or shift stock against the bed of the template, the blade pointing towards the soffit and agreeing with the line upon the face of the template. It is advisable to write the size of the opening, the name of the arch, and the number of courses upon the template, and also to apply the center (Fig. 178), upon which the arch will be turned, to the striking out, ticking off the courses upon it, and squaring them through; this will act as a guide to keep the proper thickness of joint when setting the work. The setting out should be on lining paper, which may be saved for future reference.

How to Cut a Semi-Arch.—Bed the brick and square the face; square the head from the face, but bevel it from the bed, the stock being placed against the bed, and the blade to the head. These bricks must be prepared for right and left hand; that is to say, with the face of the brick turned towards the body, half the beds should point towards the right and half towards

the left. Then prepare a radiating box 10 in. wide in the clear, and rather longer than the template, the sides of which, worked from a square line across the bottom, radiate exactly as the template, Fig. 173, also having the cutting mark upon each side exactly opposite each other. Great care must be taken that the box is accurate, and it is advisable to try the first radiated brick upon the bedding slate, with the original template. Two bricks, right and left hand, may be placed in the radiating box, with their faces to the sides and their soffits to the cutting marks, and sawn close to the top edges of the sides of the box (the latter being protected with tin), and finished with the file, taking care to file away from the front arris of side of the box, so that the former may be perfectly sharp; then, in a lengthening box (Fig. 171), face downwards, and with the soffit placed tight against a straight-edge held across the end, cut off to a length of 9 in.

If the arch is more than 9 in. on the face, then, before radiating, the course must be made up in length. Taking an arch 12 in. deep on the face, as an instance, and dealing with a course having a stretcher towards the soffit, the stretcher will be cut off 8 in. in length, and the opposite bevel obtained in the lengthening box. A bat over 4 in. in length, bedded, faced and beveled, will be fitted to the top of this, the template applied, the brick scribed to the length of the cutting side, and to the square mark on the bed, the two marks on the brick connected by the scribing saw, and sawn off square with the face. By this means the course is cut off to length, and the top bevel obtained at the same time.

It may here be noted that the 9-in. lengthening box

can be used for any odd measurements, by nailing a stop or fillet across the bottom of the box and parallel to one squared end, according to the length required, the worked end of the brick being placed against the stop, and the piece not required cut off to the end of the box.

For an arch having a 9-in. soffit, it will be readily understood that a face stretcher would have to be taken to a depth of 4½ in. in a reducing box and backed up with a properly squared and beveled bat, and that for a soffit stretcher the brick would be bedded, the face beveled for the soffit, and the header, acting as the face, squared from the bed and soffit. By placing this brick soffit downwards in a reducing box 4½ in. deep, the opposite bevel, after sawing, would be worked upon it; being afterwards made out, on the face, by a bedded, squared, and beveled bat, and cut off to length, to the template.

Every arch should be keyed in with a stretcher towards the soffit; and it will be found that, counting the courses in half the arch, and including the key, if there be an odd number, then there will be a stretcher, for the start or upon the skewback, and a stretcher for the key; if an even number, then a header for the start, and a stretcher for the key.

Arch with Moulded Soffit.—In arches with moulded soffits, although the end in view, with respect to bevels, etc., is the same, the mode of working is somewhat different. The section of the mould required must be cut upon two boards, $10 \times 4\frac{1}{2} \times \frac{1}{2}$ in., screwed together, the edges shot and squared, and the moulding cut upon them while thus fixed, so that they shall be exactly similar; the edges representing the face and soffit may be protected by tin, and they

should be fastened one on each side, exactly opposite each other, to a box having a stout bottom and two sides only, and being about 10 in. in the clear after the moulds are fixed (Fig. 172), the bricks being properly bedded and roughly squared upon the side which is not intended to be the face. The bevel is taken from the template in the usual manner, and marked upon the bottom of the box, both right and left, with the back of the stock against the front edge of the box and the hind part of the blade on the bottom; the roughly squared edge of the brick between the roughly squared face and the bed is fixed against the line or lines thus marked (if there be room, two bricks at a time may be cut, one for right hand and one for left); the saw is taken through the moulded soffit and the top face, and then with file, barrel, etc., the brick is finished, being beveled, moulded and faced at the same time. When the brick is taken out of the box, should the soffit, or face, be not quite true, the bed is rubbed to fit *them*, the square and bevel being used for this purpose. The remaining operations are the same as in plain-gauged arches.

Setting.—The center, Fig. 178, having been fixed with folding wedges beneath it, so as to make it easy of careful removal after the arch is set, should be tested for accuracy.

Axed arches are set in fine mortar, the joint being either struck, or raked out, and afterwards pointed, to give it a fancied resemblance to gauged work. Gauged arches and gauged work generally are set in lime putty, as already described. The putty is served to the setter in a putty tub. This is a box open at the top and with beveled sides, being about 15 × 12 in. at the top, but smaller at the bottom, and about 9 in.

deep (Fig. 169). The setter, keeping the putty frequently stirred, and having knocked and brushed the dust off the brick, holds it lightly on the top of the putty, takes up just sufficient to form the joint, removes a small quantity from the center, makes the joint true at the edges, puts the brick in position, and lightly taps it to make it solid. Arches are started from the right and left hand, and worked up towards the key, which is put in last. When the arch is completed in its place, it is grouted in with Portland cement, a joggle having been formed in the brick by cutting a groove 1 × ¼ in. in the middle of it; this grouting in with Portland cement greatly strengthens the arch. In years past, a bead was formed with the joint, and the work left. But now, any irregularity in the face, mouldings, etc., is corrected by means of files, pieces of barrel, brick, handstone, etc., both brick and joint being left flush and brushed down with a soft brush.

The Segment Arch (Fig. 177½).—Opening, 3 ft.; rise, 6 in.; face, 12 in. Draw an indefinite base line, and at right angles to it above and below draw an indefinite center line. Upon the base line set out the opening AB half each side of the center line CD, and above the base line measure off the 6-in. rise in E; then with the point of the compasses at A, and taking any distance greater than half AE, describe arcs above and below the base line; with the same distance in the compasses and the point at E, cut these arcs in X. Then a line being drawn through these intersections and meeting the center line, will give the radial point O.

With the point of the compasses at O, and the pencil extended to A, describe the soffit, passing through E and terminating at B. Next with the straight-edge at O and passing through A, draw the skewback or

abutment, and the same with B; then measure up from the soffit upon the center line 12 in., and with the point of the compasses at O, and the pencil extended to the 12 in., draw the extrados terminating at the skewbacks. Now proceed as in the semi to procure the template, with this exception, that the work terminates on the skewback, and not on the springing line. Having procured the template, fill in the arch. The courses will be divided into 8-in. stretchers and 4-in. headers, taking care to key in with an 8-in. stretcher towards the soffit. This arch having a skewback, care should be exercised that this is properly cut and set, especially if it be in ordinary building bricks. A mould or gun, as it is termed, should be taken off the drawing and applied to the reveal; the projecting or triangular portion answering to the fall of the skewback (Fig. 177½). Here A being placed against the reveal, the skewback is built up to B.

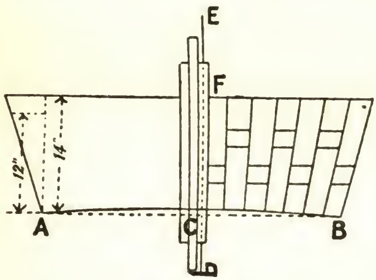


Fig. 185.

In this, as also in the semi-arch, if the student wishes to draw the arch only, then the extrados may be pricked over at 3 in. as already described, and the face joints filled in from the radial point by means of a straight-edge passing from it to the divisions on the extrados.

Moulded Segment.—When a moulding is worked upon the reveal and continued round the soffit of the segment, a new difficulty presents itself in the intersection

of the mouldings between these two. Again, take a 3-ft. opening, 6-in. rise, 12-in. face, with a $2\frac{1}{4}$-in. moulding, the half being shown (Fig. 179). Set out the soffit and reveal as in the plain gauged segment; then to the right of the reveal line measure off the depth of the moulding $2\frac{1}{4}$ in., draw the outside moulding line parallel to the reveal line, and continue above the base line. Then on the center line and above the soffit again measure off the $2\frac{1}{4}$-in. moulding, and with the point of the compasses at O and the pencil extended to the $2\frac{1}{4}$-in., describe the moulding line parallel to the soffit, and meeting the reveal moulding in point F. From the point F to B draw a line. This will be the miter line. The skewback will be taken, as before, from the point O, but will begin at the point F. The arch will be cut precisely in the same way as the moulded semi, with a slight addition to the top course of the moulded reveal and the first course of the arch, i.e., where the intersection takes place. Two pieces of board, $10 \times 3 \times \frac{1}{2}$ in., should be planed and shot while screwed together, so that they shall be perfectly true in themselves and to each other; the lines H and I will be produced each way and the moulds laid to coincide with the bricks S, Fig. 180; then by means of the straight-edge, which is made to coincide with the produced lines as shown, the lines H and I will be accurately drawn upon the moulds. They should then be cut to this shape, and are known as shoe moulds. A moulded brick, being placed on its bed in between two shoe moulds, can, by means of the saw and file, be properly mitered as M, Fig. 179; the moulded end of No. 1 course of the arch should be then cut to tightly fit it. All other operations for the moulded segment will be the same as in the moulded semi.

In axed arches with field-moulded bricks (bricks having the moulding cast upon them in the brick-mould while in the green state, and afterwards burnt), such as bull-nosed and mopstaff beaded, the treatment of the miter will be nearly the same, only, that instead of the miter being solid, as in M, Fig. 179, the portion BF in the latter figure will be cut upon the top of the brick, and the skewback taken from that, Fig. 181.

Camber Arch.—This is sometimes called a straight arch; but it has really a slight rise, the rule being to give the soffit a rise of ⅛-in. for every foot of opening. The reason for giving the rise is to counteract the optical illusion which causes the arch, if straight upon the soffit, to appear to sag, or camber, the wrong way. When a slight rise is given, the arch appears to be straight upon the soffit. It would be impossible to strike such a slight sweep with a radius rod; the rise is therefore given by means of the camber slip. A camber slip should be made of good hard wood that will not shrink or twist; mahogany or oak is excellent for this purpose. It is always convenient to keep one in stock, and if it be long enough it will answer for any opening. There are not many camber arches over 7 ft.; therefore a convenient length for the camber slip would be about 8 ft. The mode of obtaining the camber slip is as follows (an extreme case is given, as being easier of illustration): Suppose the opening to

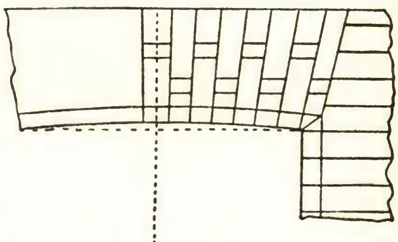


Fig. 186.

be 3 ft., and the rise 1 in. to the foot, then the camber slip 3 ft. long would have a rise of 3 in.; take a rod 3 ft. long, measuring in width 1 in. at each end and in the middle 2½ in., or in other words, having in the center half the required rise; shoot this piece from the middle to the two ends perfectly straight, thus forming two triangles, as it were, upon a common base; call the center B, and the two outside points A and C (see Fig. 182). Then take a piece of board a little over 3 ft. long and 6½ in. wide by ½ in. thick, planed both sides, and one edge shot, draw a center line upon the face of it, and 18 in. each side of it draw two other lines; call the center line E, and the two outside lines D and F, Fig. 183. Upon the center E, 6 in. up from the shot edge, drive in a pin, and upon D and F, 3 in. up from the shot edge, drive in other pins. Then take the first piece, Fig. 182, already prepared, and with a pencil held at the center B, apply it to pin F, and with A on the same piece pressed against the pin E, move the piece with the pencil from F to E, describing half the curve, Fig. 184. Repeat this process on the other side, moving the center B with the pencil from D to E, and the curve will be drawn; then cut the curved side to the line drawn, and the camber slip will be completed. To prove the camber slip, lay it down and mark all round it, then reverse it, and if the camber slip coincides with the lines drawn by it, it will be correct. In using the camber slip always work from a center line.

The next consideration is what amount of skewback should be given to the camber arch. By the old system the opening was taken as a radius and a line cut upon the center line as a radial point for the skewback; but this has been found to give too great a skewback

and becomes a source of weakness. The proof of this is as follows: First considered as a wedge, sustaining a vertical thrust or load. If a wedge were made too flat, when driven home the ends would become bruised and split. Again, let it be supposed that the camber arch is taken out of the segment, or let it be considered that behind each camber there is an invisible segment; then, as far as strength is concerned, the more of the segment contained in the camber, the stronger the arch; experience shows that the longer the radius, the less the rise, or the flatter the segment, and hence the more of it in the camber The less acute skewback, if produced to meet a center line, will give the desired longer radius. Therefore a good datum to work to, as a general rule, is to give each skewback 1 in. fall for every foot of opening, when the arch is a foot upon the face.

To Set Out the Arch.—Opening, 3 ft.; face, 14 in., Fig. 185. Draw the usual base line, with a center line perpendicular to it; set out the opening AB, half each side of the center line CF. Then, with the center of the camber slip upon the center line, and the edge just coming out at the points A and B, draw the camber or curved line.

Then to obtain the skewback. At A and B erect faint perpendiculars, and upon these lines measure, from the base line upwards, distances of 12 in. and 14 in.; take square lines to the left of A and right of B, and upon these lines at the 12-in. height measure off 3 in., the allowance for an arch 12-in. face and 3-ft. opening; then from A and B, through the outer points of the 3-in. lines draw the skewbacks indefinitely. These skewbacks would answer for any depth of face for this size opening. Now take a point upon the

center line, 14 in. up from the base line, place the center of the camber slip upon this point, the curved edge at the same time passing through the two 14-in. points upon the perpendiculars erected at A and B, and while in this position draw the outer or extrados line. Prick over the courses upon this line, as in other arches, starting with the key and working out to the skewback. If it were possible to produce the skewback downwards to meet the center line, then this point might be treated as the radius point wherewith to fill in the approximate key. But should this not be practicable, the number of courses taken upon the extrados line, by reducing the distance taken in the dividers, will have to be pricked over on the intrados line, taking care, at the same time, to have an equal proportion on each side of the center line. Having pricked over the top and bottom lines accurately, draw in the approximate key, but producing the line to the right of the center line, both above and below the arch. Call this produced line DE. Now, to procure the approximate template; as before, prepare a piece of ½-in. board, 3¼ in. wide and 18 in. long, both sides planed and one edge shot. Let the shot edge be exactly placed against the left-hand line forming the key, and, with a long straight-edge placed over the board, the edge coinciding with the produced line DE, mark the template. Cut and shoot it accurately, and traverse as before. Having obtained the template, fill in the courses, and fix the cutting mark. It has already been seen that in the semi and segment the courses have been equal in length, and the bevels alike, but in the camber the bevel and length will differ in each course; the longer bevel and length being in No. 1, and the shorter in the key. An illus-

tration of the treatment of No. 1 course will serve for all the courses. No. 1 course is the first course upon the skewback. Place the template with its bed side upon the right-hand skewback line, and the cutting mark upon the camber line. Then, where the edges of the template touch the camber lines, both top and bottom and on both edges make pencil marks. One mark (the cutting mark, it will be remembered) is already made. Square these marks upon the edges, and connect the two top and the two bottom across the face of the template; this will give the length of the course upon the cutting edge, and the bevels both bottom and top. Serve each course in the same way, and number their bevels upon the template. The arch is 14 in. on the face; it will therefore be filled in as 8-in. stretcher, 2-in. closer, and 4-in. header, in one course, and 4-in., 2-in., and 8 in., in the next, and so on, as before, keying in with a stretcher towards the soffit. The skewback will be treated as in the segment, and all other operations in setting, etc., will be the same. Great care should be taken in grouting in this arch, as it is one of the weakest in construction.

It must be remembered, in cutting this arch, that the different bevels have to be taken off and marked "right" and "left," upon the bottom of the box, as was done in the case of the one bevel in the segment arch.

Moulded Camber (Fig. 186).—The moulded camber should be treated similarly to the moulded segment, the outside line of moulding being drawn in with the camber slip, parallel to the soffit, meeting the outside line of moulding on the reveal and forming the miter. The skewback must be taken extra to the moulding, or, in other words, it must be drawn from the outside

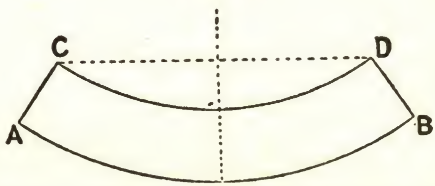
point of the miter, so that if a $2\frac{1}{4}$-in. moulding be used in a 3-ft. opening, with an arch 12 in. on the face, the top point of the skewback would fall $5\frac{1}{4}$ in. away from the reveal. The shoe mould, etc., would be obtained as in the segment arch.

Camber on Circle.—Arches circular on plan are not to be recommended, as being of weak construction. But where it becomes necessary to use them, they should be strengthened by means of an iron bar bent to the shape.

The mode of setting out this arch and obtaining the template is very simple. Let Fig. 187 be the plan of the sweep to be covered by a camber arch, of which AB and CD are the outer and inner faces respectively. Develop AB by pricking it over with compasses, or bending a thin lath round the curve and bringing it out as the straight opening EF. Upon EF construct the camber arch in the ordinary way (Fig. 188), and produce the lines of skewbacks, bringing them down indefinitely below the soffit or base line. Next develop the inside line CD of the plan in a similar manner to AB, cutting off its actual length on a rod; then lay the rod in between the skewbacks which are produced below the soffit, till, while keeping it parallel with the base line, it accurately fills in between the skewback lines. Now, with the rod in this position, draw a line which may be termed a sub-base line, and draw the camber line upon it. Next procure the template as already directed, taking care that it be long enough, not only for the ordinary arch, but also to cover the bottom or sub-camber line. Having got the bevels, cutting mark, etc., while the latter is upon the soffit line proper make another cutting mark also upon the bottom soffit line, and the template will be ready for a camber on circle.

When cutting the arch, the upper cutting mark must be used for the face of the arch-brick, while keeping it at the soffit, and the lower cutting mark will be used for the back of the brick, while keeping it in a similar position. By cutting this brick, the student will learn how to prepare the radiating box, one side of which will be higher than the other, according to which side of the arch is being cut. Or, in other words, let it be

Fig. 187.



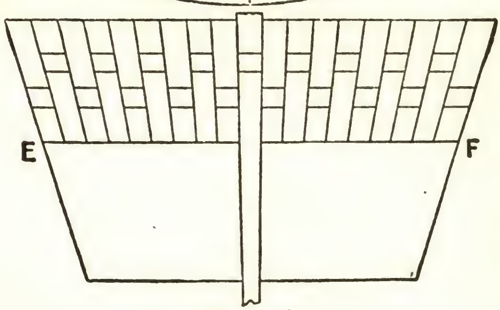


Fig. 188.

granted that the left, or leading hand of the arch, is the one to be radiated. Then, having drawn a square line across the bottom, and parallel to the tail of the box, with the face of the brick turned to the body, and the soffit towards the right hand, prepare the box by placing the *upper* cutting mark of the template against the body, and the *lower* one of the other side, to this line.

Should the curve be very sharp, it would cause the arch, if left after the above operations, to appear, on the face, as a series of short lines. To avoid this a pair of moulds 10 in. long, having the same sweep as the plan of the arch struck upon them, and 4½ in. only at their widest point, should be prepared. Each course, being laid in between these moulds according to the angles their beds make with the base line (for instance, the key-brick will lie at right angles between the curved sides), would, when cut, receive the same curve as the plan, Fig. 188. It must be borne in mind, when putting in the skewbacks, that they are radii of the same sweep.

Should the face of this or any arch be 18 in. deep, then the bonding will be as in Fig. 190.

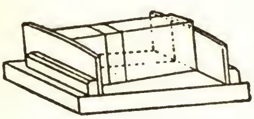


Fig. 189.

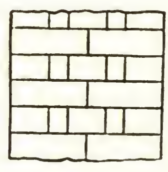


Fig. 190.

It will be noticed that the skewback of the 12-in. segment, Fig. 179, does not come out to the top of the course, making it necessary to put in a small piece of brick; and again, that the 14-in. camber, Fig. 186, is not in depth the multiple of a brick course, necessitating the cutting of an inch course over the arch.

To do away with this cutting, arches in these and similar cases may, while maintaining the same bonding on the face, be increased in depth, care being taken that the proportion between the stretcher, header, and closer is relatively the same. Thus, by

dividing the 15 in. in the latter case into seven (the number of closers in a stretcher, header and closer combined), then taking four of these for a stretcher, and two for a header, etc., the stretcher will be found to measure $8\frac{4}{7}$ in., the header $4\frac{2}{7}$ in., and the closer $2\frac{1}{7}$ in.

Equilateral or Gothic arch (Fig. 191).—Opening, 3 ft.; face, 9 in. Draw an indefinite base line, upon it erect a perpendicular center line, and set out the opening AB half each side of it. With the point of the compasses at A, and the pencil at B, draw the curve or

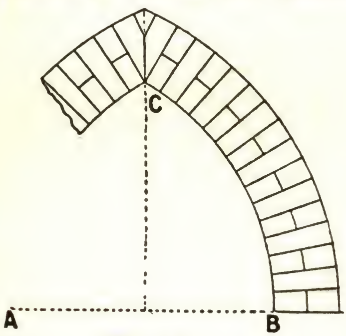


Fig. 191.

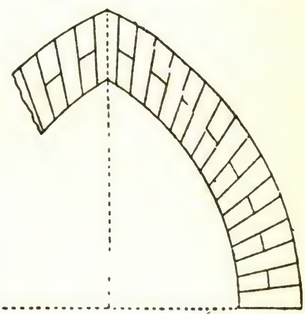


Fig. 192.

half-intrados BC; then with the point at B and pencil at A, draw the other half AC. With the same radius points, and the compasses extended to 3 ft. 9 in., describe the outer line or extrados. When set out properly, this arch, unlike all other arches, has no key-brick, but a joint in the center. It will therefore be necessary, when pricking over, to allow half a course on each side of the center line, as though providing for a key-brick. If lines be drawn from A and B to C, it will be seen that each half of the arch is really a segment, and the template will be obtained in the

same way, only, where the courses meet on the center joint, these extra long bevels thus formed will have to be taken from the drawing and marked on the template.

The above is not only the correct method for setting out the Gothic arch, but is also the strongest, as the courses are normals to the curve. But many object to keying, as it is called, with a joint, and insist upon having a key-brick. In the latter case (Fig. 192), the arch has to be set out, as all other arches, starting with half a course each side of the center line, and then

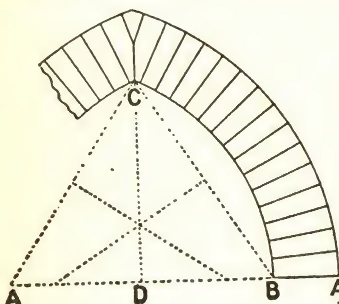


Fig. 193.

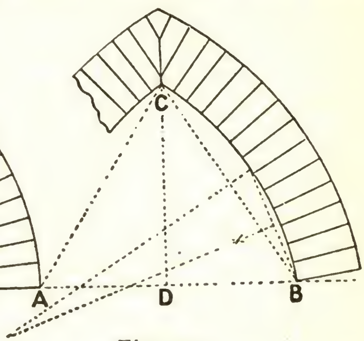


Fig. 194.

pricking over to the springing. The approximate key, which is cut as a bird's mouth, is then filled in from the center of the base line, and the approximate template obtained and traversed until it is accurate. The courses are then filled in with the latter. Under these new conditions, the courses, not being normals to the curve, will all differ in length and bevel. These will be obtained and marked on the template, in the same way as in the camber (Fig. 185).

The Modified Gothic (Fig. 193).—When the equilateral arch has to be reduced in height, by remembering that

the two sides are two segments only, the setting out becomes very clear. Again, taking the 3-ft. opening and 9-in. face, set out the base and center lines and the opening AB. Upon the center line set up the reduced height DC; join AC and CB. Bisect AC and CB with lines square to them, and produce to the base line. Where these meet will be the radial points from which to fill in the sides, the template being obtained as in the equilateral arch (Fig. 191). This, like the Gothic arch, may be filled in from the center of the base line, forming a key-brick, the lengths and bevels differing for each course.

Lastly, should the curves on AC and CB need modifying (Fig. 194), these may be brought down by treating them as segmental arches, constructing the base line, and marking the height of the curve upon the center line. Mouldings on these arches are a very simple matter, being treated, when filled in from the radial point, as the segment, and from the center, as the camber arch. In neither case is there the difficulty of the miter to meet.

The Elliptical Arch.—There is no curve in arch cutting that requires more care than the ellipse, and there is no arch in which faulty setting out, or a cripple, as it is termed, is more easily detected, especially by the trained eye. First, let it be quite understood that it is impossible to set out the ellipse by means of the compasses, though a very near approach may be obtained, when the rise has not to be taken into consideration, by the following methods:

Case 1. Fig. 195; opening 3 ft.; face 9 in.—Lay down the base line with a center line drawn at right angles above and below it indefinitely and the opening AB half each side, as before. Divide the opening AB

into four parts in the points C, D, E. With the point of the compasses at C, and the pencil at A, describe an arc; then, with the same distance in the compasses, but with the point A, cut this arc in F. Repeat this on the other side of the opening, and again cutting this arc in F. Through F and C, and F and E, draw lines meeting at the center line in G, and extended indefinitely above F. Then, with the point of the compasses at G and extended to F, describe the remainder of the curve, or intrados, from F to F. Now, going back to C, and the pencil extended 9 in. beyond A, describe the extrados terminating at the line FG. Repeat this on the other side of the opening. Then, with the point at G, and the pencil extended, draw the topmost part of the extrados. It will not be apparent that in between the lines GF there is a segment arch, the template for which will be obtained as in that arch; and that the other two portions are parts of a semicircular arch, and again the template will be obtained as for the latter arch. This is the strongest method of filling in, but the appearance of having two distinct shapes of bricks upon the

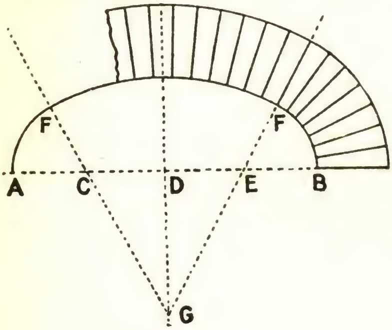


Fig. 195.

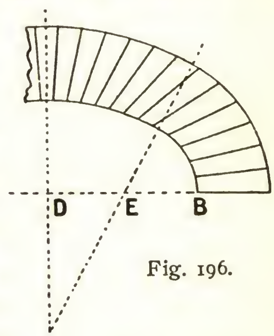


Fig. 196.

face is certainly objectionable. The difficulty may be overcome by filling in the arch the same as the camber, or by pricking over the extrados and filling in from the center of the base line for the approximate key. The bevels and lengths, of course, will differ, but the bricks will be alike on the face (Fig. 196).

Case 2. Fig. 197.—Another method of setting out by means of the compasses, with a given rise, the height of the rise bearing a liberal proportion to the opening. Set out the 3-ft. opening as before, calling it AB, and the 14-in. rise CD. Join DB; cut off CD from CB in the point *d*; take the remainder *d*B, and cut off D*b* from DB in the point *b*. Taking any distance in the compasses greater than half B*b*, and with the point first at *b*, then at B describe arcs cutting each other above and below *b*B. Through these intersections draw a line cutting the base line in the point E and the center line in the point F; then measure from A, fixing a point, G, upon the base line similar to E. Then E, F, G, will be the radial points from which to draw the arch as before.

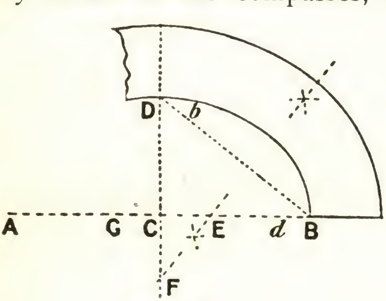


Fig. 197.

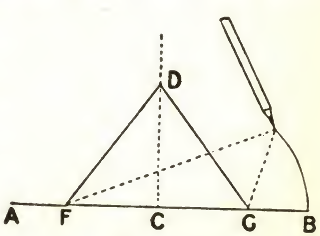


Fig. 198.

Case 3.—Fig. 198 is the string method, answering

very well for rough elliptical arches which have to be covered with plaster. Set out the opening, or major axis, AB, and the center, or half minor axis, CD. Taking the distance CA in the compasses, with the point at D, cut the base line at F and G. Then, having fixed pins at F, D, G, tie the end of a piece of string or thin wire at F, pass it round D, and tie at G. Remove the pin D, insert a pencil in the loop, and, with the string or wire extended as far as it will go, describe the curve.

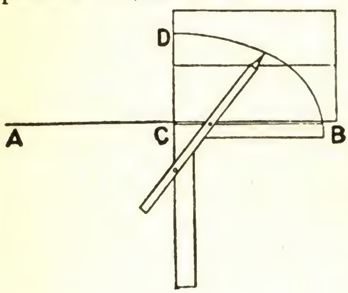


Fig. 199.

Case 4.—Neither of the above, though useful in their way, can be compared to the trammel, which is the best practical method to be recommended to brick layers. (Figs. 199 and 200).

Set out the opening AB upon the base line half each side of the center line CD, which will be drawn indefinitely below as well as above the base line. Prepare a square, the sides being about 2-in. wide and ½-in. thick, with a slight bevel taken off the under side of the outer edges; fix the square, the edge of one side coinciding with the center line, but below the base line, and the other with the right hand, and answering to the half of the base line. Next take a rod (which will be known as a trammel rod) with fixed pencil point;

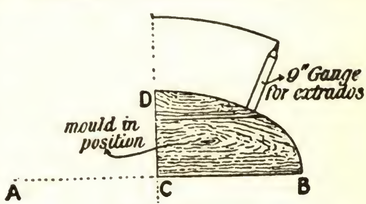


Fig. 200.

measuring along the rod from the pencil point, fix a screw, with the head downwards, at a distance equal to the rise CD. Again measuring from the pencil point, fix a similar screw equal to the distance CB, i.e., half the opening. Now take some thin boarding, kept together by ledges, equal to rather more than half the opening in length, and more than the height of the rise in width, with the bottom and left-end edges answering to the right-hand side of the base and center lines, shot true and square to each other. Fix the mould in position, with the bottom and end edges coinciding with the center and right-hand half of the base lines. Then, with the trammel rod, the head of one screw working horizontally under the bevel along the top edge of the square, and the other vertically up the square, describe half the soffit upon the roughly prepared mould, which should be properly and truly cut to the curve. This may be termed the master mould. Practice only will give perfection in striking this curve.

It is impossible to attach too much importance to the use of the master mould. The brick-cutter should set out his work to it, and also take the tickings upon it for the center; the carpenter should use it as his mould for making the center; and then it should be sent to the joiner's shop, for the purpose of setting out the curve for the head of the frame. Lamentable results have occurred through these three trades working independently.

In setting out the arch, Fig. 200, the mould should be fixed in position, the bottom of it to the base line and the end to the center line; then, having drawn the intrados line, a gauge the required depth of the face should be cut, and while one end is worked round the

master mould, the other, having a pencil attached, will describe the other curve, or extrados. The template may then be obtained and the arch filled in as before. It will be seen from the description that theory differs in many points from practice. The extrados in theory is not parallel to the intrados. In theory also, each face course, or voussoir, being normals to the curve, would differ in shape, and, though not quite impossible, would be most expensive in practice.

In setting out elliptical arches consisting of alternate blocks of brick and stone, the divisions should be in

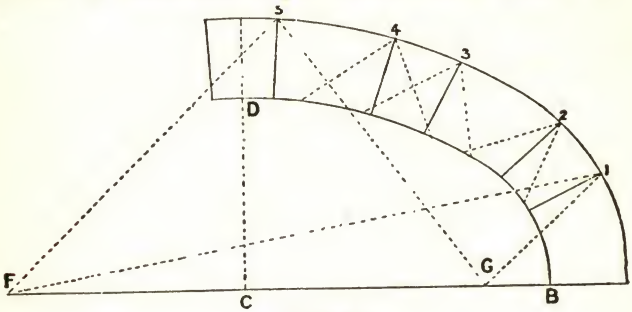


Fig. 201.

the proportion of 5 to 3 or 6 to 4 respectively; and in large arches each division should be set out normal to the curve, and separate templates obtained for each block of brick and stone. For instance, take an arch for a 7-ft. opening, 2-ft. 3-in. rise, 12-in. on the face (Fig. 201), to be filled in with red bricks and cut stone, but starting with red brick and keying in with stone. Set out the opening in either of the ways as shown, then upon the extrados, set out the courses of brick and stone, either as 5 to 3 or 6 to 4, whichever comes in most conveniently. In this case 5 and 3 appear to work in the best; so, starting with the key, tick in

stone equal to three courses of brick, next to this five courses of brick, then stone, and so on. Number the divisions 1, 2, 3, 4, 5. Now find the foci to the outer curve. This is done by taking the distance CB in the compasses, placing the point of it at D, and cutting the base line in F and G. From tick 1 on the extrados draw lines to F and G, bisect the angle thus formed, and the bisector will be one of the joints required. Serve the other joints in the same way, and then get the templates for each division of brick.

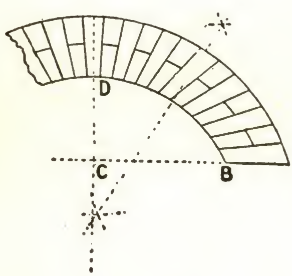


Fig. 202.

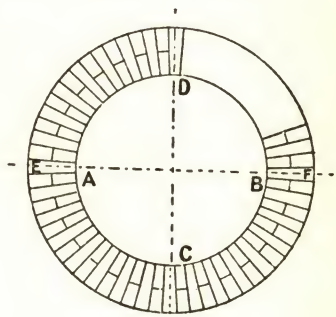


Fig. 203.

It would be as well, too, in large elliptical arches, say for 12-ft. openings, built of *brick* only, to make divisions in this manner, and obtain templates for each; for only those who have anything to do with these arches know the difficulty of obtaining one or even two templates for a very large ellipse.

The scheme arch, Fig. 202, is one which, while starting off a level bed, has a less rise than a semicircular arch. Let AB be the opening, with the center line CD, CD being also the 12-in. rise. Obtain the curve ADB as if for a segment, then extend the compasses for the 9-in. extrados, carrying it down to the

springing line. Prick over the extrados, putting in the approximate key from the center C, and traversing the template until it comes out to the springing line. It will be noticed that the courses differ somewhat in bevel and length and must be taken off as in the camber.

Bull's Eye Arch, Fig. 203.—The curve of this arch is a complete circle, AB and CD being the base and center lines crossing each other at right angles, the curve and face being drawn and the template obtained as described in the construction of the semi-arch; the only difference is in the disposition of the two side key-bricks, which are placed as E and F.

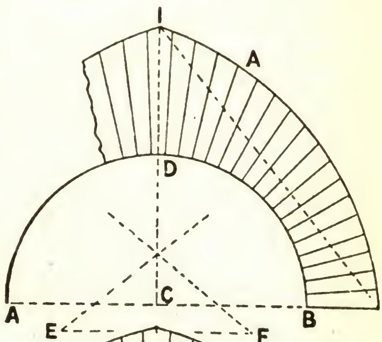
The above are the principal arches, but there are various others which are often used as a mixture of two of the foregoing, and are as follows:

The Semi-Gothic, Fig. 204, has a semicircular intrados, but a Gothic extrados. Let AB be a 3-ft. opening, with CD as the center line. Set out the ordinary semi; then upon the base line beyond A and B measure off the face, say 9 in., and with either of the methods described for drawing the Gothic, proceed to draw the extrados according to the height required. In this instance the radius is taken from E and F. It will now be necessary to prick over the soffit of the arch to get the approximate key, putting in a trial key first to ascertain how the brick will hold out towards the top. Having fixed the approximate key, get the template as previously shown. The soffit bevels will be the ordinary semi-bevel, but the extrados bevels will all differ as will the length of the courses. When drawing the arch only, fill in from the center C.

The Ellipse Gothic Arch, Figs. 204 and 206.—Let AB be the 3-ft. opening, 1 ft. 6 in. of which is each side

of the center line, and rise CD. Divide AB into three equal parts in E and F. From E and F, with the radius FB and EA, describe arcs as in the ellipse struck with the compasses, terminating at the points H and G. Join HD and GD by faint lines. From H and G through F and E draw faint, indefinite lines. Bisect HD and GD, and produce lines square to these. The points in which these latter lines meet the lines passing through HF and GE will be the radial points for the top part of the arch. The extrados will be drawn by extending the compasses from the radial points by which the intrados is struck. Two templates will be used, one answering for the two arcs, and the other for the two segmental portions of the arch.

Fig. 204.



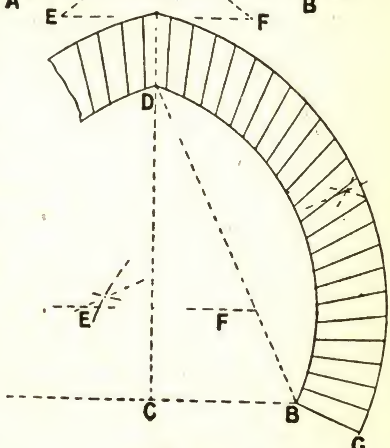
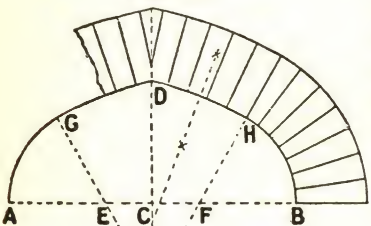


Fig. 205.

The Horse-Shoe or Moorish Arch, Fig. 205.—This is an arch but very seldom seen, but it is well that the practical man should be acquainted with it. Set out the

3-ft. opening AB, and the center line and 3-ft. 3-in. rise CD. Join AD and BD; bisect DB; set up the rise and describe the curve as in the ordinary segmental arch; from the radial point E, through B, draw the skewback BG; measure the face upon BG; extend the compasses, and draw the extrados, terminating at the opposite end of G upon the produced center line CD. Treat the other side of the arch in the same way. Although filling in the arch as though there were two segments is far stronger, still a better appearance is gained by pricking over the extrados, filling in the bird's-mouth key from a point made by the skewback being produced to cut the center line, and then traversing the template, and treating the arch as a scheme. The courses will have different bevels, and will be slightly different in length.

Fig. 206.



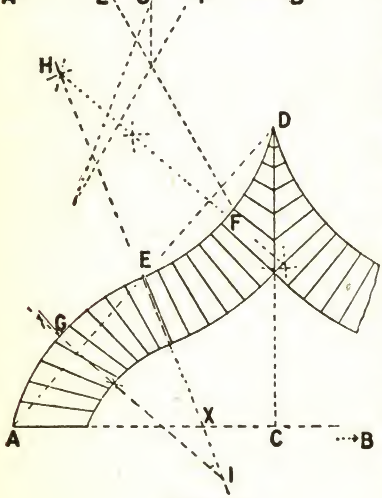


Fig. 207.

The Ogee, Fig. 207, is another peculiar arch, weak in construction, and to be used only as an ornamental feature. Let AB be out to out of extrados, and CD the rise of the same. Draw a line from A to D, and

bisect it in E. Bisect DE, producing the center line both above and below it, as in the segment, and the same with EA. Upon DE set up the rise upon that part of the center line pointing to DB, and upon EA set up the rise upon the opposite side. Then describe the curves DFE, EGA, in the ordinary way. From the point H, by extending the compasses 9 in., put in that portion of the intrados from the line EI to the center line CD, and from the point I, by decreasing the distance in the compasses 9 in., draw in the part of the intrados from EI to the base line AB. Deal with the bottom portion of the ogee as a scheme, by getting the shape of the template from the point X, made by EI cutting the base line; and the top part as a segment, obtaining the template from the point H. Traverse the templates, accurately fill in the courses, and mark the bevels and lengths.

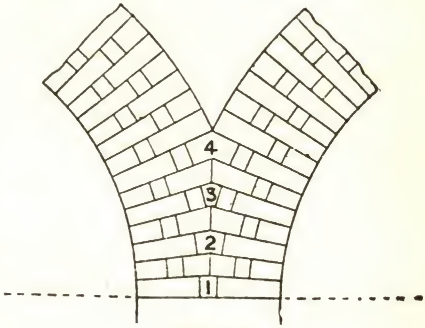


Fig. 208.

Arches Springing from the Same Pier, but Differing in Size.—It frequently occurs—in bays, for instance—that while there is one large opening in the middle, there may be a smaller one upon one or each side of it, and that one skewback of the large and one of the smaller arch will be adjacent to each other upon the same pier. Adhering to the rules for skewback, the latter will be at different inclinations, thus presenting a most unsightly appearance. To overcome difficulties such

as these must be left to the judgment of the practical man. As an example, two camber arches, one for a 4-ft. and the other for a 2-ft. opening, both 12 in. on the face, have skewbacks of 4 in. and 2 in. respectively upon the same pier. Here an average should be struck, giving each arch a skewback of 3 in.

As another distance, let there be two segment arches, one opening 4 ft. and the other 2 ft., both of the same rise. In this case the smaller arch should be sacrificed to the larger, keeping the same rise in both, but giving the smaller the same skewback as the larger, thus converting it into a scheme.

Intersection of Haunches.—When two arches spring from the same pier, and the depth of their combined faces more than equals the width of the pier, then a proper intersection of their haunches should be arranged. In Fig. 208, two semicircular arches, 14 in. upon the face, spring from an 18-in. pier. The bond on the faces is kept, as far as possible, down to the springing. But where the outer lines of the haunches meet, the intersection is alternated with saddle-bricks, 1, 2, 3, 4, and upright joints. Moulds will have to be procured with which to cut the saddle-bricks.

It will be seen that it is impossible to get the saddle-brick No. 4 out of a brick flat, but it may be obtained by placing the brick on edge, which in this and other similar cases is permissible, the difference being made up by filling in at the back

THE NICHE

For years past, to cut and set a niche has been considered a clever achievement indeed; but, as a matter of fact, it is really not so difficult as it appears. By careful attention to directions and rules here given,

any practical man of ordinary ability will be able to accomplish it.

Semicircular Niche.—That is to say, semicircular both on plan and on elevation, Fig. 209. First to set out and cut the body, taking the opening as 3 ft. Draw the opening AB, and at right angles to it the center line DC. From the center D, with DA as radius, describe the semi ACB, then extending the compasses 4½ in., put the 4½-in. thickness of work in the body of the niche. Taking 2¼ in., or, if necessary, 2¼ in. full in the compasses, prick over from C to A, but on the outer curve, as many 2¼ in. as will make

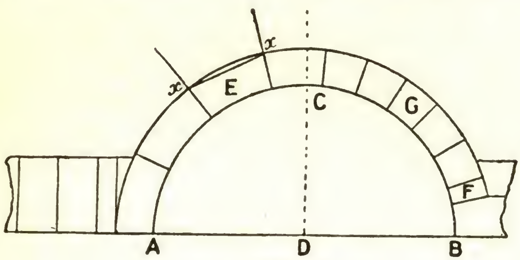


Fig. 209.

Fig. 210.

an even number of stretchers and a half, so that half a stretcher shall come each side of the center line. Then with 2¼ in. again in the compasses, prick over the side CB, putting in the headers and closers to bond with the stretchers on the side CA. The first header at B will appear as a stretcher upon the face, and the first stretcher at A as a header, having a closer next it. Moulds must now be cut for the stretcher acting as face header at A, for the stretcher E, for the headers acting as face stretcher at B, for the closer F, and the bat headers G.

The mode of preparing the moulds is as follows;

Taking the stretcher E as an example, produce the joints XX, take two pieces of board, 10 × 4¾ × ½ in., screwed together, and having one edge shot. Fix the boards down over E with the shot edge from X to X. With the radius DC, and from the center D, describe upon them the inner curve. Then with a straight-edge from D to the produced lines X, draw in the radii, but allowing rather more than $\frac{1}{32}$ in. for joint and tinned edges to the mould. Have the mould accurately cut and fitted to the lines, and after tinning they will be ready for use (Fig. 210). They are fixed in a box with the edges which were placed at XX downwards. The bricks are prepared by being properly bedded, and one face roughly squared; they are placed in the cutting box, two at a time, the roughly squared face downwards, with the beds tight up to the moulds and fixed. The two ends and two faces are sawed completely over, and finished with a file. Then, having been tested for accuracy by squaring from the bed to face and ends, they are brought to thickness, and are then ready for the body of the niche. The other moulds and bricks will be prepared in the same way. In setting, the plumb rule, level, and a hand mould answering to the semi ACB, are all that will be required to keep the work true. It should also be tried occasion-

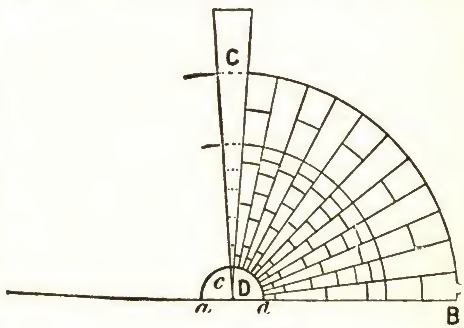


Fig. 211.

ally, to see that the work is kept to the proper height.

Next to set out and cut the head or hood, Fig. 211. Draw the base line AB, and set up the center line DC. With the point of the compasses at D, and the radius DB, describe the extrados ACB. Then, with the compasses decreased, draw in the 9-in. face. Prick over the extrados as directed in other arches, putting in the approximate key, and obtain the template, which, unlike that for other arches, will extend from above the outer face to the point D. Having obtained the accurate template, place it in position as the key, and with its point at D. Then with the point of the compasses at D, and the pencil extended to where the

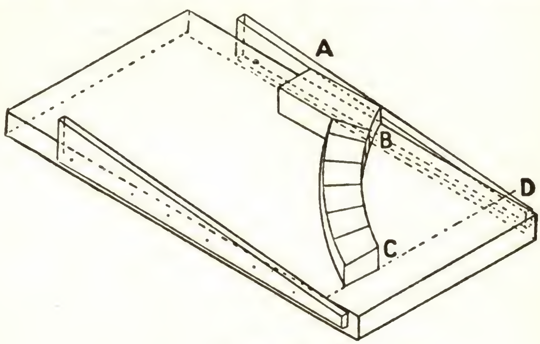


Fig. 212.

template becomes ½ in. in width, draw the boss *acd*. Fill in the arch and hood with the template, letting the courses extend from and include the face, home to the boss. Obtain the bevel and the cutting mark as though for the ordinary semi or face arch.

Now take the courses as prepared for the body of the niche; half a course will answer for the right-hand side of the arch, and half for the left; but instead of

squaring from the bed to the inside face, use the arch bevel, and bevel from the bed to the face, rubbing the bed to make it answer the bevel, and also the squared ends.

The radiating box is now necessary, and is prepared as follows: Make a stout bottom 2 in. in thickness, in length about 2 ft. 6 in., i.e., somewhat longer than the template, the width being 2 ft. 3 in., or DC of the body plus 4½ in. thickness of work, with a little to clear. For the sides of the box, take two pieces of board 2 ft. 6 in. long and 4 in. wide, properly shot and tinned on the top edge. Upon the face of one of these boards tack the template, with the cutting edge of the latter flush with the tinned edge of the former. In this position the prepared side will project below the template, and with the bed of the template resting upon the bed of the bottom of the box. Securely nail it there. Scribe the cutting mark upon the tinned edge and remove the template. Go through the same process for the other side, taking care that the cutting marks on both sides are immediately over a line squared across the tail of the box, and the radiating box will be complete, (Fig. 212).

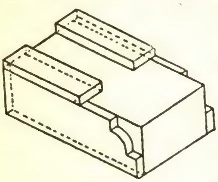


Fig. 213.

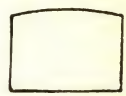


Fig. 214.

Mode of Cutting.—Of the prepared courses, place the brick which answers to the face stretcher, or long header B of the body, in the box, with the face to the right-hand or A side of the box, and the soffit to the cutting mark, and, measuring away from the soffit of this brick at the cutting mark, and along the side of the box for the radial point D, describe the quadrant BCD. Place the remainder of the course to this

curve; fix it down; then, keeping the wire saw at right angles to the sides of the box, saw the course right over, and keeping the file in the same position, properly finish it, working away from the edge so as to preserve the arris. With the opposite hand go through a similar proceeding, and the same with the next courses. Cut the solid boss, and the hood will be ready for fixing.

Fixing or Setting.—A solid head or turning piece is not at all necessary. In fact, when using this, the most important part of the work, which when finished will be seen, has to be guessed at while fixing. Instead of this, a hollow semicircular rib to fit the head or body should be made, having an outside rib only, about ½ in. thick, so that while the setting proceeds the inside may be seen. Upon this will be marked from the drawing the soffit joints of the face arch, so as to ensure that the work is rising properly. Then, starting upon each side, proceed to fix the work. If the front turning piece should be found insufficient when nearing the key, then a lesser but similar semicircular mould may be used further in. Finally properly grout in the work with Portland cement.

The Elliptical Niche.—This is similar to the semicircular but elliptical upon plan. Taking the opening as 3 ft., set out the body upon plan, using the trammel method. Fill in the stretching and heading courses as before, but in this case pricking over the outer and inner curves for the proper shape of the bricks, and obtain the moulds as already directed. The head will be semicircular and, although the body is elliptical, there will be but one bevel, the courses being placed in the box, not to a quadrant, but to the shape of half the elliptical curve.

Moulded Soffit to Niches.—It will be readily seen that, should the edges of the opening and the soffit of the arch be moulded, this would be cut on the moulds answering to the bricks A and B, Fig. 209, and would be cut upon these bricks at the same time that they were being shaped for the niche.

LABELS TO ARCHES AND NICHES

Moulded labels going over camber arches need very little description, being merely moulded bricks as stretchers or headers set over the arch. But when a label has to be fixed over a semicircular or segmental arch or niche, it is very evident that if straight moulded bricks were run over such arches, their beds would appear as a series of short straight lines, looking most unsightly. It is, therefore, apparent that a curve struck with the same radius with which the arch was set out must be run on each, and they will also have to be cut to a radial template, in a similar way to an arch; the course, 3 in. or 4½ in. in depth, as the case may be, being set on the top of the arch. If it be 3 in. deep, then the pricking over on the extrados will be 4½ in.

The bricks will be moulded one at a time. The mode of doing this is to use a pair of clip moulds, which will hang one on each side of the brick (Fig. 213), placed in the box, bed or soffit upwards; then, after sawing and roughly filling it, the brick should be finished off with a piece of stout sheet iron having a convex curve of the same sweep as the extrados of the arch worked upon it (Fig. 214). By keeping the sheet iron upright while using it, the curve will be worked not only upon the soffit of the brick, but throughout the moulding. After the label has been set, sufficient

substance will have been left upon the top edge of the label to admit of its being worked off with a hand-stone, either to the eye or to a prepared mould.

THE ORIEL WINDOW

The oriel window, whether in stone or brick, is a most artistic feature in a building. Stone lends itself more readily to the safe carrying out of this work than brick. When built of the latter material, a frame of light ironwork treated with oil or painted to prevent oxidation may be constructed, with the ends either built into the main wall, or bolted firmly to the joists. But, according to circumstances, so the mode of keeping the work in its place must be determined by the practical man.

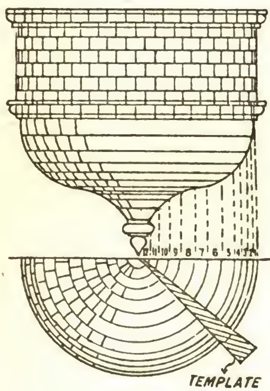


Fig. 215.

To cut the oriel, set it up in elevation equally each side of a center line. Now, if the courses are to be equal in thickness, the center line, or height, must be divided off into 3-in. courses. The courses will then appear upon the curve as unequal in thickness. But if they are to appear equal in thickness, prick round the curve at 3 in. The courses will then really be unequal (Fig. 215, in which the setting out is according to the latter system). Set out a pair of moulds for

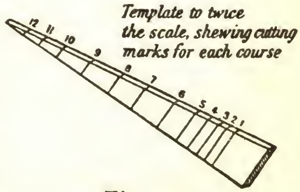


Fig. 216.

each course, with the curve worked upon each. Draw a horizontal line beneath the elevation, and from each course upon the curvature of the latter, drop perpendiculars to the horizontal line. Then from the center to each of these points will be the radius with which to draw the plan of each course. Prick round the outer curve and obtain the template, which must reach from the outer line to the radial point. Different cutting marks will be placed upon the template for each course, working from the outer one towards the radial point (Fig. 216). From this plan it will be seen how many bricks will be wanted for each course. To cut the work, bed the bricks, square one face, and mould and take to thickness at the same time. Then place them in the radial box at the cutting mark to which they belong, and after sawing and finishing with the file, they are ready for setting.

In setting, take care to half-bond the courses and properly flush up with Portland cement. An inverse mould fixed at each end, and ribs or moulds answering to different courses upon plan, will be found useful to test the work as it proceeds.

MEASUREMENT OF BRICKWORK, POINTING, ETC.

Most bricklayers know how to use the foot rule in measuring ordinary work, but, having attained the measurement, the difficulty arises as to how to square or cube the quantities thus obtained. Another difficulty also met with is how to take the measurement of awkward shapes, e.g., gables, arches, etc. This chapter, therefore, is intended to help those who have no knowledge whatever of the subject.

In the building trades, measurements are taken as foot run, foot super, or square and foot cube.

Foot Run relates to length only; for instance, drains, tile-creasing, cutting under 6-in. wide over circular arches, cement fillets, etc., are taken and priced at the foot rule. In this there are 12 in. to a foot, and 3 ft. to a yard.

Foot Super, or Square.—Here length is multiplied by width or height; a paved floor, so many feet long by so many feet wide, will have so many feet super, or square, of paving. In a square foot there are 144 square inches. To make sure that this is so, draw a square 12 in. long by 12 in. wide, and divide up into inches; it will be seen that there are 144. But in the building trades, both with square and cube measurements, twelfths of feet are reckoned upon. So 6 square feet 72 square inches would be written 6′ 6″ super. There are also 9 square feet in a square yard. This may be proven by laying down a square 3 ft. long by 3 ft. wide, and dividing into squares 12 in. by 12 in., when nine squares will have been formed Foot super is used in measuring facings, paving, tiling, etc.

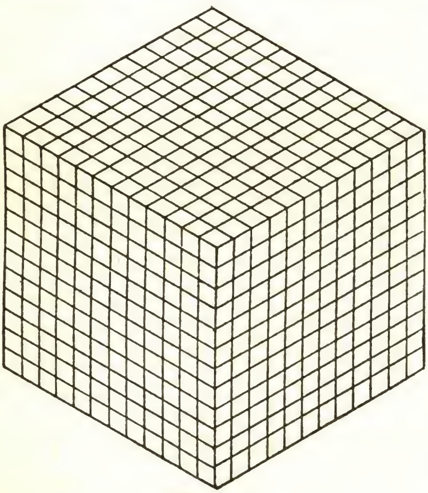


Fig. 217.

Cube measurement is length × (multiplied by) thickness × depth or height. Thus, in finding the cubic

contents of an 18-in. square pier, say 6 ft. high, it would be stated as $6' \times 1'\ 6'' \times 1'\ 6''$. In the cubic foot it will be seen (Fig. 217) that there are 1728 cubic inches. That is to say, that 1728 wooden cubes, $1 \times 1 \times 1$ in. may be built up to form a cube 12 in. long, 12 in. broad, and 12 in. deep. Here again, instead of reckoning 1728 inches, the cubic foot is divided into twelve cubes, and 6 cubic feet 864 cubic inches is written as $6'\ 6''$ cube. There are 27 cubic feet in a cubic yard, as may be seen by making twenty-seven cubes $12 \times 12 \times 12$ in. and piling them together to form a cube $3 \times 3 \times 3$ ft. Cubic measurement is used for excavations, concrete, etc.

Before squaring dimensions, a perfect mastery of the multiplication tables up to 12 times is necessary. A thorough knowledge of these tables will also be sufficient for division when needed. Thus, knowing that 12 times 9 are 108, then 12 into 108 equals 9, and 12 into 112 equals 9 and 4 over, or 9 into 108 equals 12, and 9 into 112 equals 12 and 4 over, etc. A constant practice in this will be invaluable in squaring dimensions.

There are several arithmetical methods of squaring dimensions, but for those who are not expert it would be better to adopt one system only. An easy and accurate method is that known as cross multiplication, or duodecimals. By duodecimal is meant multiplication by twelves. Take as an instance **5 ft. 7 in. × 2 ft. 4 in.**, or, as it is written

$$
\begin{array}{rrr}
5' & 7'' & \\
2' & 4'' & \\
\hline
11' & 2'' & \\
1' & 10'' & 4'' \\
\hline
13' & 0'' & 4''
\end{array}
$$

Here start to multiply 5 ft. 7 in. by the 2 ft. and say twice 7 are 14; 12 into 14 equals 1 and 2 over; place the 2 under the 4, and carry 1. Next, twice 5 are 10, and the 1 carried equals 11; place this under the 2 ft. Proceed with the multiplication by 4 in., and say 4 times 7 are 28; 12 into 28 equals 2 and 4 over; place the 4 in the line under 11 ft. 2 in., but one place to the right of the 2 in., and carry the 2. Then 4 times 5 are 20, and the 2 carried make 22; 12 into 22 equals 1 and 10 over; place the 10 under the 2 in. and 1 under 11 ft. Add these two lines, starting with the first figure to the right; so 4, with nothing added, equals 4, bring it down in its place; 10 and 2 (or 10 plus 2) are 12; 12 into 12 equals 1 and none over, place 0 under the 10, and carry 1; the 1 carried plus 1 and 11 are 13, place the 13 under the 1; and the answer will be 13 ft. Whenever in the place twice removed to the right of the feet (or where 4 appears in the last result) the figure is 6 or over, reckon this as one more to the place to the right of the feet (or where 0 appears in the last result), but when under 6 discard it. Thus, if the last answer had been 13′ 0″ 7″ call it 13′ 1″, but being 13′ 0″ 4″ only, it should be taken as 13′.

Cubing.—Let 6 ft. 4 in. × 2 ft. 11 in. × 3 ft. 6 in. be the dimensions, written as

$$\begin{array}{r} 6' \ 4'' \\ 2' \ 11'' \\ \underline{-3' \ 6''} \end{array}$$

Proceeding as before (see below), begin by multiplying 6 ft. 4 in. × 2 ft. and say twice 4 are 8; this cannot be divided by 12, so place it under the 11. Twice 6 are 12; place this under the 2 ft. Then multiply by the

11 in.; 11 times 4 are 44; 12 into 44 equals 3 and 8 over; place the 8 under the 12 ft. 8 in. but one place to the right of 8, and carry the 3. Then 11 times 6 are 66, and the 3 carried make 69; 12 into 69 equals 5 and 9 over. Place the 9 under the 8, the 5 under the 12, and add the two lines; 8 and 0 equals 8, write it in its place under the 8; 9 and 8 are 17, 12 into 17 equals 1 and 5 over, place the 5 under the 9 ft. and carry the 1; 1 and 5 are 6, and 12 are 18 ft., place the 18 in its proper position as feet; and the result so far is 18′ 5″ and 8″. Multiply this by 3 ft. 6 in. placing the 3 under the 18, and the 6 under the 5. As before, first multiply by the feet and say 3 times 8 equals 24; 12 into 24 equals 2; carry the 2 and place 0 in the lines under the 3 ft. 6 in., but to the right of the 6. 3 times 5 equals 15, and 2 equals 17; 12 into 17 equals 1 and 5 over; place the 5 under the 6 and carry 1. 3 times 8 are 24, and the 1 carried makes 25; place the 5 under the 3 and carry 2. 3 times 1 are 3 and 2 equals 5; place it to the left of the last 5, making 55. Then multiply by the 6 in. and say 6 times 8 are 48; 12 into 48 equals 4 and 0 over; again place the 0 under the 55′ 5″ 0, but one place to the right of the 0, and carry the 4. 6 times 5 are 30, and the 4 carried, 34; 12 into 34 equals 2 and 10 over; place the 10 under the 0 and carry 2. Then multiply 18 by 6, adding on the 2, and making 110; 12 into 110 equals 9 and 2 over, place the 2 under the 5, and the 9 under the right hand 5 of the 55. Add the two lines together; 0 coming first, bring down; 10 and 0 are 10, bring down the 10; 2 and 5 are 7, bring this down; 9 and 5 are 14, put down the 4 and carry the 1; 1 and 5 are 6, put the 6 to the left of the 4. The answer is 64′ 7″ 10″ cube or 64′ 8″ cube. Dividing this by 27, we get 2 yards 10′ 8″ cube.

$$\begin{array}{llll}
6' & 4'' & & \\
2' & 11'' & & \\
\hline
12' & 8'' & & \\
5' & 9'' & 8'' & \\
\hline
18' & 5'' & 8'' & \\
3' & 6'' & & \\
\hline
55' & 5'' & 10'' & \\
9' & 2'' & 10'' & 0'' \\
\hline
64' & 7'' & 10'' & 0''
\end{array}$$

Timesing.—When a dimension occurs several times over, it is written thus—

$$2\left|\begin{array}{ll}5' & 7'' \\ 2' & 4''\end{array}\right.$$

which means that the result of 5 ft. 7 in. × 2 ft. 4 in. is to be multiplied by 2; and looking to rules given, it will be seen that this is 13 ft. × 2, which is 26 ft.

Again, a quantity written thus—

$$3.2\left|\begin{array}{ll}5' & 7'' \\ 2' & 4''\end{array}\right.$$

or dotting on, it is called, means that the result of 5 ft. 7 in. × 2 ft. 4 in. is to be multiplied by 2 added to 3 or 5; and the whole result would be 65 ft.

Digging is taken at the yard cube, and depends for price upon the depth, and the distance the earth has to be wheeled or carted.

The least amount of depth of trench for a 14-in. wall, including footings and concrete, would be 2 ft. 3 in.; the width being 3 ft. 3 in. Then, taking it that the measurements of digging to trench for a 14-in. wall 20 ft. long are required, the trench itself would be 20 ft. plus $(3' \, 3'' - 1' \, 2'')$ equals 22 ft. 1 in. × 3 ft. 3 in. × 2 ft. 3 in. The 2 ft. 1 in. being projection of

footings, concrete, etc., at each end; and the amount of concrete 22 ft. 1 in. × 3 ft. 3 in. × 1 ft. 3 in. These dimensions may be obtained by drawing the plan of the footings and concrete for length and width, and setting up the section for depth, as already shown on page 8.

Concrete of less thickness than 12 in. or where under pavings, etc., is taken at per yard super.

In brickwork the difficulties of measuring are somewhat greater. In some places practice is to reduce all work of 1½ bricks thick and upwards to a standard of 272 ft. super 1½ bricks thick, which is called a rod; the actual measurements being 16½ ft. × 16½ ft. × 1⅛ in., or 306.2812 cu. ft., reckoned in practice as 306 cu. ft. Walls under this thickness are generally specified with the work they entail, e.g., struck joints both sides, pointed, circular, etc. When measuring footings, for instance, multiply the average length by the average thickness, and then by the height. When taking the average thickness, first add the width of the top course to the width of the bottom course in bricks, and divide by 2; thus for a 2-brick wall, 2 plus 4 ÷ 2 equals 3. Then the average thickness will be 3 bricks, or 2 ft. 3 in. (When the bottom course is doubled, take one of these courses separately, and afterwards add.) Taking the length of the wall to be 20 ft., the average length of the footings will be 20 ft. plus (2 ft. 3 in. average thickness – 1 ft. 6 in. width of neat work) equals 20 ft. 9 in. The height of the footings, as already shown, including one course of the wall, will be five courses, or 15 in., and the quantity of footings equals 20 ft. 9 in. × 1 ft. 3 in. 3 bricks thick equals 25 ft. 11 in. or 26 ft. of work 3 bricks thick. By multiplying 26 ft. by 6 (the number of half bricks in 3

bricks) and dividing by 3 (the number of half bricks in 1½ bricks), the work will be brought to the standard measurement, 26 ft. × 6 ÷ 3 = 52 ft.

In ascertaining the quantity of digging, to trenches, concrete, and footings, for a rectilineal building, much labor may be saved by taking an average. Let ABCD (Fig. 218) be the plan taken through the 3-brick wall of a building 50 ft. × 30 ft. out to out. If miter lines be drawn from A to E, B to F, C to G,

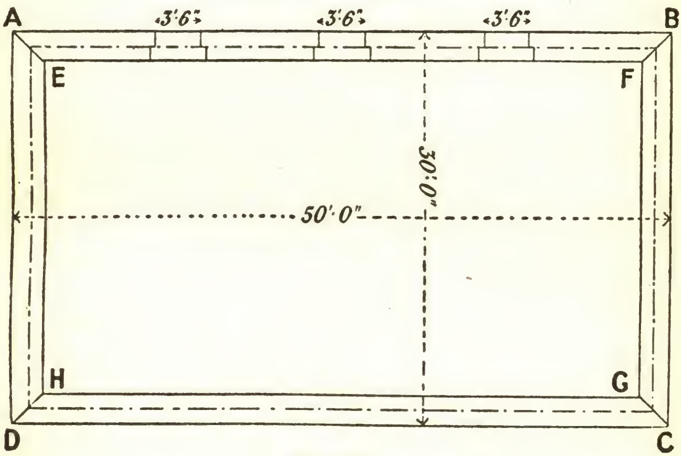


Fig. 218.

and D to H, and lines midway between the inner and outer lines, but terminating upon the miter lines, be also drawn, the average length of the walls will be found to be 2/47 ft. 9 in. and 2/27 ft. 9 in. Then the digging for trenches will be 2/47 ft. 9 in., or 151 ft. × 5 ft. 6 in. × 3 ft. 10 in., which equals 3183 ft. 7 in. cube, or 117 cu. yd. 25 cu. ft. Concrete 151 ft. × 5 ft. 6 in. × 1 ft. 10 in. equals 1522 ft. 7 in. cube or 56 cu. yd. 11 cu. ft. Footings average thickness equals (3 plus 6) ÷ 2

equals 4½ bricks; the height including one course of wall equals 1 ft. 9 in., which equals 151 ft. × 1 ft. 9 in. × (9 half bricks ÷ 3 half bricks or) 3 equals 792 ft. 9 in. or 793 ft. super of reduced work. To this will be added one of the bottom doubled courses, which equals 151 ft. × 3 in. × (12 ÷ 3 or) 4. This equals 151 ft. of reduced work, and together 793 ft. plus 151 ft. equals 944 ft. or 3 rd. 128 ft.

Brickwork is usually measured first as ordinary stock work, length by height, the thickness stated, extra per foot super being allowed for facings; and all openings, arches, etc., deducted. It is usual to measure floor by floor, starting from the footings to the under side of the ground floor joists, and so on.

Taking Fig. 218 as a guide, and supposing the quantities of the wall AB 15 ft. in height, faced with red builders and pointed, with a weather joint, and containing the three 6 ft. × 3 ft. 6 in. window openings, are required, the stock work will measure 50 ft. × 15 ft. 3 bricks thick 750 ft. × (6 ÷ 3) or 750 ft. × 2 equals 1500 ft. reduced work. But from this must be deducted (3/3 ft. 6 in. × 6 ft.) plus (3/4 ft. 3 in. × 6 ft.) 1½ bricks thick equals 139 ft. 6 in. 1500 ft. – 139 ft. 6 in., equals 1362 ft. 6 in. or 5 rd. 2 ft.

The extra for facings, including pointing, will be 50 ft. × 15 ft. super, and added to this six reveals 6 ft. × 14 in., and three soffits of arches, say, allowing for rise, 4 ft. 14 in. From this again will be deducted the superficial measurement of the three window openings; 50 ft. × 15 ft. equals 750 ft.; 6/6 ft. × 1 ft. 2 in. equals 42 ft.; 3/4 ft. × 1 ft. 2 in. equals 6 ft.; together 750 plus 42 ft. plus 6 ft. equals 798 super; deduct 3/6 ft. × 3 ft. 6 in. equals 63 ft. super; leaving 798 ft. – 63 ft. or 753 super.

Chimney Breasts.—Measure the width by the height, stating the thickness of the work; deduct the fireplace opening. The flues are taken in as if solid, pargeting to these being numbered. Ovens and coppers are also measured as solid, deducting the ash-hole only.

Arches.—The face and soffit are measured separately, and afterward added. The camber arch (Fig. 185) will serve as an example for measuring. The opening being 3 ft., but taking 12 in. as depth of face, add one skewback, making it 3 ft. 3 in. × 12 in. (depth of face), 3 ft. × 4½ in. soffit; the superficial measurement in this case will then be 4 ft. 4½ in.

For all radial arches, pass the tape round the face, midway between the intrados and extrados, arrive at the amount, and multiply by the depth of the face; then serve the soffit in a similar manner, multiplying by the depth.

Taking Fig. 176 as an example, the face is found to measure 3 ft 9 in. × 12 in. equals 3 ft. 9 in., soffit 3 ft. 2 in. × 4½ in. equals 1 ft. 2 in. and together 4 ft. 11 in.

The practical man sometimes finds a difficulty in multiplying by such awkward quantities as 6. ft. 9 in. 4½ in.; but, by a little thinking, these become quite easy.

Feet multiplied by feet will give square feet, e.g., 12 ft. × 12 ft. equals 144 ft.

Feet multiplied by inches equal twelfths of feet; e.g., 20 ft. × 6 in. equals $\frac{120}{12}$ sq. ft.; inches multiplied by inches equal square inches.

Feet multiplied by 6 in. will give half the amount multiplied; thus 12 ft. × 6 in. equals 6 ft. square.

Feet multiplied by 3 in. will give one quarter of the amount multiplied; 12 ft. × 3 in. equals 3 ft. square.

Feet multiplied by 9 in. will give the last two results

combined; 12 ft. × 9 in. equals (½ of 12) equals 6, plus (¼ of 12) equals 3, together 9 ft. square.

Feet multiplied by 4½ in. will first be taken as the last and half of that again taken, because 4½ in. is half of 9 in.

Feet multiplied by 2¼ in. would be half of the above, for the same reason.

Feet multiplied by 4 in. will give one-third of the amount multiplied, 4 in. being one-third of 12 in.

Feet multiplied by 8 in. will give twice the result of the last, 8 in. being two-thirds of 12 in.

To reduce cubic feet of brickwork to superficial feet of standard thickness, deduct one-ninth, e.g., 40 ft. × 20 ft. three bricks thick equals 1600 ft. reduced work; compare with 40 ft. × 20 ft. × 2 ft. 3 in. equals 1800 cu. ft.; take from this one-ninth of 1800 ft. or 200 ft., leaving 1600 ft. reduced work as before.

Practical men usually take pointing by the square of 100 ft. super.

To measure gables or pediments, take the central height by half the base for superficial measurement, and for brickwork according to the bricks thick.

To find the area of a circular opening, multiply the square of the diameter by 0.7854; e.g., diameter of circle, 10 ft.

10 ft. × 10 ft. equals 100 ft. × 0.7854 equals 78.54.

To measure fair cutting to a circle, multiply the diameter by 3.1416; e.g., diameter of circle, 10 ft.

10 ft. × 3.1416 equals 31.416.

For a semicircular arch, half the above, e.g., diameter of semicircular arch, including depth of face on each side, equals 10 ft. Fair cutting round the arch equals 31.416 as above for the whole, ÷ 2 equals 15.708.

In measuring brickwork over 60 ft high from the ground, it should be kept separate, and divided into heights of 20 ft., viz., 60 to 80, 80 to 100, etc. The reason for this is that the higher the work goes the more expensive it becomes to build.

Keep the following work separate:

Brickwork built overhand.

Raising on old walls, stating the height the work commenced from ground level.

Circular brickwork.

Half-brick partition walls.

Sleeper walls.

Measure hollow walls as solid.

The following work is usually taken at the yard super: Lime-whiting; pointing when not included with the facings; brick-nogging, including timbers, stating if built flat or on edge; cement floated face, stating thickness, if to falls, and if floated or troweled; all kinds of paving; wall tiling, giving full descriptions.

Work measured by the foot super: Damp-proof courses; trimmer arches; fender walls; sleeper walls; half-brick partition walls; arches generally, except gauged; facings, keeping the different kinds separate.

Work measured at per foot run: Cement filleting, cuttings under 6 in. wide, pointing flashings, cutting chases for pipes, brick on edge, and other kinds of copings.

Items numbered: Bed and point frames; setting stoves and ranges, fixing chimney pots, ventilating bricks, parget and core flues, rough relieving arches.

Hoop-iron bonding is measured at per yard run, adding 5 per cent to the length for laps, stating if tarred and sanded, and making no deductions for openings.

Brick-cutting Tools.—Rough cutting: 1, the large trowel; 2, the club hammer and bolster, for cutting with greater exactitude than with the trowel; 3, the cold chisel for the cutting of chases and for general work.

Fair cutting, hard bricks: 1, the tin saw for making an incision ⅛ of an inch deep, preparatory to cutting with bolster; 2, the chopping block, which is an arrangement of two blocks of wood so fixed as to support a brick in an angular position convenient for cutting; 3, the scutch consists of a stock and a blade, the latter generally formed of a flat file about 10×1 in., sharpened at both ends and fixed in the stock by means of a wedge. This displaces, and is an improvement on, the old brick axe, as the blade can be removed and sharpened readily; it is used to hack away the rough portions on the side of a brick after the edges have been cut by the tin saw and bolster.

Fair cutting, soft bricks: 1, the saw consists of a frame holding the blade, which consists of twisted soft steel or malleable iron wire (No. 16 B.W.G.), and is used for cutting soft rubbing bricks; 2, the rubbing stone is a circular slab of gritty stone 20 in. in diameter, for rubbing the faces of bricks to a true surface; 3, the mould is a wood box enclosing bricks that are to be cut to a shape, the sides of the box being formed to that shape, and the edge over which the saw blade works is protected by a strip of zinc; 4, the square, bevel, and compasses are used in the setting out of work.

Pointing tools consist of: 1, small trowels for filling up joints of new brickwork; 2, the pointing rule, which is a feather-edged straight-edge with two small pieces ⅜ in. thick nailed at each end to keep the rule away

from the wall and allow the trimmings to fall through; 3, the frenchman, for trimming joints, consists usually of an old table knife, with the end ground and turned up, as shown in plate; 4, the jointer, used for tuck pointing in old work.

BRICKLAYER'S MORTAR

Mortar.—The mortar is composed of one of lime to two or three parts of sand, or from one of Portland cement to one to four of sand. Lime mortar sometimes has cement added to it to increase its strength and hasten its setting.

Lime mortar should not be used when fresh nor in an untempered condition, as in that state its cohesive value is small and it is difficult to work; but after making should be left two days at least, then turned over and beaten up again.

This tempering gives it the property of working evenly and fat. Cement mortar should be used as soon after making as possible, as the setting action commences immediately after mixing and any further working up of the mortar lowers its ultimate strength.

Building During Frosty Weather.—All brickwork should be suspended during frosty weather, as its stability is endangered by the disintegration of the mortar by the frost while it is wet. When the work is urgently required it should be carried up in cement mortar in the intervals between the frost; but all the freshly built portions should be carefully covered and protected on any recurrence of the frost.

Technical Terms.—Course is the name given to the row of bricks between two bed joints; the thickness is taken as one brick plus one mortar joint, in this work;

unless otherwise stated, it will be considered as 3 in., or, as technically described, four courses to the foot.

It usually requires about 1⅛ barrel of lime and 1 yd. of sand to make the mortar for 100 bricks, and one man with 1¼ tender will lay 1,500 to 2,000 bricks per day; that is, four masons and five helpers will lay about 8,000 brick, but this should be reckoned on straight walls.

The same proportions of sand and lime, or cement and lime, may be used also for masonry.

Allow 12 bushels sand to one barrel.

Allow about .0012 bushels fire clay for each 100 brick and 1 barrel of Portland cement to 800 brick.

A load of mortar is equal to one cu. yd. It requires 1 cu. yd. of sand and 9 bushels of lime; it will fill 30 hods.

A bricklayer's hod measures 1 ft. 4 in. × 9 in., equals 1,296 cu. in. It holds 20 bricks and weighs about 113 lbs. when full.

A single load of sand is equal to 1 cu. yd.; a double load, 2 cu. yd. A measure of lime is one load.

One barrel of fire clay will make a thin mortar for 1,000 bricks.

One part cement to two parts sand for cement mortar.

Mortar.—One part of lime to 3 or 3½ parts of sharp river sand; or 1 part of lime to 2 of sand and 1 of blacksmith's ashes.

Brown Mortar.—One-third lime, two-tnirds sand, and a small quantity of hair. This is for plastering.

Coarse Mortar.—One part of lime to four of coarse gravelly sand.

One rod of brickwork requires 1 cu. yd. of lime and 3½ single loads of sand; or, 36 bushels of cement and 36 bushels of sharp sand.

One yard, or 9 superficial feet, 1½ bricks thick, requires 2¼ bushels of cement.

One superficial yard of pointing brickwork in cement requires ⅛ of a bushel.

Some kinds of cement set so fast that it is not safe to mix more than can be used within twenty minutes.

Mortar made of cement, worked after it begins to set, becomes worthless.

The following are the rules generally used by masons in figuring brickwork:

Corners are not measured twice.

Openings over two feet square are deducted.

Arches are counted from the spring.

Pillars are measured on the face only.

To find the number of bricks in a wall.

4½	in. wall per superficial foot....	7 bricks.
9	in. wall per superficial foot....	14 bricks.
13	in. wall per superficial foot....	21 bricks.
17	in. wall per superficial foot....	28 bricks.
22	in. wall per superficial foot....	35 bricks.
26	in. wall per superficial foot....	42 bricks.
30	in. wall per superficial foot....	49 bricks.

And seven bricks additional for every half brick added to the thickness of the wall.

One foot superficial of gauged arches requires 10 bricks.

One thousand bricks closely stacked occupy about 56 cu. ft.

One thousand old bricks, clean and loosely stacked, occupy 72 cu. ft.

Stock or place bricks generally measure 8¾ × 4¼ × 2¾ in., and weigh from 5 to 10 pounds each.

GENERAL SPECIFICATION CLAUSES

MATERIALS

BRICKS

1. All bricks intended for use under this Specification must be the best of their respective kinds, hard, square, sound, well-burnt, and even in size. No brick must absorb more than one-sixth of its dry weight in water during one day's immersion. Samples of each kind, selected at random from the load, must be deposited with and approved by the architect before any of that particular kind are laid.

NOTE.—If the bricks are not specified from particular makers the following may be added to the foregoing clause:

And the architect is to be informed from what manufacturers the bricks are being obtained, if he so desires.

All bricks shall be carefully handed from the carts and stacked, and no broken bricks or bats are to be brought upon the ground.

2. All hard, sound, clean, and approved old bricks, obtained from pulling down the old buildings on site, may be re-used where directed.

3. The stock bricks are to be (obtained from . . . .) *or* (equal to the manufacture of . . . .) similar in all respects to the samples deposited with the architect.

4. The stock bricks for facings are to be carefully selected for their evenness of color and face, and the visible arrises must be undamaged.

5. The pressed (red) facing bricks are to be (obtained from . . . .) *or* (equal to the manufacture of . . . .) similar in all respects to the samples deposited with the architect. In all cases the visible arrises must be undamaged.

6. The hard, wire-cut gault bricks are to be (obtained from . . . .) *or* (to be equal to the manufacture of . . . .) similar in all respects to the samples approved by the architect.

7. The cutters or rubbers are to be obtained from.......... or other approved manufacturer, equal in quality, free from all lumps and flaws, and similar in all respects to those approved by the architect.

8. The salt-glazed facing bricks must be slip-glazed, and are to be obtained from............or other approved manufacturer They must be fairly uniform in tint and equal in all respects to samples approved by the architect.

9. The salt-glazed bricks are to be obtained from............ or other approved manufacturer, fairly uniform in tint, and equal in all respects to samples approved by the architect.

10. Reveals, arches, projecting piers, etc., in salt-glazed work are to have bull-nosed angles. Any squints, etc., to be in salt-glazed quoins to required angle.

11. The enamel-glazed bricks are to be obtained from ....or other approved manufacturer. Samples of the required color or colors must be deposited with and approved by the architect before any of this work is executed. Provide enamel-glazed bull-nosed angle bricks for reveals and arches to windows and door, projecting doors, etc. Provide all enamel-glazed quoins to required angles for squints, etc.

12. The firebricks are to be obtained from............or other approved maker (raw and unburnt) *or* (thoroughly burnt and vitrified), and equal in all respects to the samples approved by the architect.

13. The smoke flue pipes (with air flues combined) are to be of the best fireclay, and of approved stock pattern, to be obtained from............, and equal to the samples approved by the architect.

14. The moulded strings, stops, cornices, angles, sills, jambs, plinths, panels, and keys, etc., shown on details, are to be obtained from the same manufacturer supplying the facing bricks, and of similar make, equal in all respects to the samples approved by the architect.

15. The coping bricks are to be (as per detail drawing) *or* (of approved stock pattern), from............or other approved maker..........inch by........inch, straight, and even colored, and all arrises and angles must be perfect.

16. The bonding bricks for hollow walls are to be obtained from............, of improved bent pattern, equal to samples approved by the architect, and of the following size: Lower

flange,......inch; middle flange,......inch; upper flange,..... inch.

17. The..........bricks for (the $4\frac{1}{2}$-inch groined arch work) are to be made by............or other approved maker, each brick cut to the proper size and radius as shown on the detailed drawing, and marked before it leaves the works with a number corresponding to that on the drawing showing its proper position in the arch.

SAND, ETC.

18. To be clean, sharp, pit or fresh-water sand, coarse grained, and of approved quality. To be entirely free from loam, clay, dust, or organic matter. If directed it must be washed, when used with cement.

19. If the lime mortar is mixed in a mortar mill, the architect, at his discretion, may allow the contractor to substitute a certain proportion of clean, hard brick, hard burnt ballast, or other approved material in lieu of sand. Such permission shall be given in writing, and shall clearly state the exact proportion of the substitute material which the contractor will be allowed to use.

WATER

20. The whole of the water required for the works must be perfectly fresh and clean, and free from any chemical or organic taint.

LIME MORTAR

21. The limes for mortar shall be the best of their respective kinds, obtained from (manufacturers approved by the architect) (the firms hereinafter specified), and shall be fresh burnt(and ground) when brought on the works.

(*Add the following if firms are not specified:*)

The contractor shall supply the architect, at the latter's request, with the names of the firms from whom the lime has been obtained.

(*Add the following if firms are specified:*)

The contractor shall satisfy the architect, if required by him to do so, that the lime is being obtained from the specified firms.

(*Add the following where ground lime is specified:*)

The contractor must satisfy the architect, by analysis or otherwise, that the lime is not adulterated or air-slaked.

22. The lime shall be thoroughly slaked at the scene of operations by the addition of sufficient water. During the process it shall be effectually covered over with sand to keep in the heat and moisture. All lime must be used within ten days of slaking.

23. The contractor shall, at his own expense, provide a proper mortar mill, worked by steam or other approved power, for the due incorporation of the materials, and all expenses in connection therewith shall be defrayed by the contractor.

24. If a mortar mill is not provided for the making of the mortar, the contractor will be required to thoroughly screen the materials before mixing to get rid of any dangerous and refractory lumps.

25. A proper stage is to be provided to receive the lime mortar when made. The mortar in no case to be deposited on the ground.

26. The materials for all lime mortars are to be measured in the proper stated proportions, in quantities sufficient only for each day's requirements.

27. Fat lime mortar must not under any circumstances be used for the purposes of the specification.

28. The stone lime mortar for brickwork above ground level shall be composed of one part of gray lime (obtained from......) and two (three) parts of sand, mixed with a sufficiency of water and thoroughly incorporated together (in a mortar mill). (The lime and sand shall be mixed together in their dry state before being put into the mortar mill.)

29. The lias lime mortar shall be composed of one part of blue lias lime (obtained from..............), and one part of sand, mixed with a sufficiency of water and thoroughly incorporated together (in a mortar mill). (The lias lime mortar for brickwork above ground level shall be made in the same manner, but in the proportions of one part of lime to two parts of the sand.) (The lime and sand in their dry state shall be mixed together on a proper stage before being put into the mortar mill.)

30. The blue mortar shall be composed of three parts of fine foundry ashes, two parts of ground stone lime, and two parts of sand

CEMENT MORTAR

31. A proper stage is to be provided for mixing Portland and Roman cement mortar upon, and the water must be added from a can with a fine rose.

32. No cement mortar that has become partially set shall be revived or re-used.

33. The Portland cement shall be obtained from............ (an approved maker), and shall be of the best quality composed entirely of thoroughly well burnt clinker ground fine enough to pass a sieve of 2,500 meshes to the square inch, without leaving more than 10 per cent behind. The cement shall not contain more than 1 per cent of magnesia and 63 per cent of lime. It shall weigh not less than 112 lb. per striked imperial bushel when lightly filled into the measure from an inclined trough placed 12 in. above the top of the measure.

Test briquettes made of the cement, mixed with 18 per cent by weight of water, shall be capable of maintaining—after seven days' immersion in water—a tensile strain of 350 lb. per square inch, the immersion to commence within twenty-four hours of the briquettes being made. The temperature of the atmosphere and water in which the test briquettes are made shall not be less than 40° Fahr. The tensile strain shall be applied at the rate of about 400 lb. per minute.

Samples of the cement when made into a paste with water and filled into a glass bottle or test-tube must not in setting become loose by shrinking from the sides, or crack the vessel.

34. The cement shall be emptied and spread upon the dry wooden floor of a covered shed to a depth not exceeding 2 ft. for a period of not less than 14 days (or such other period as may be considered necessary) and shall be turned over from time to time as may be directed by the architect.

35. The cement shall be delivered on the works in such quantities as to allow sufficient time for testing before being required for use, and the contractor shall be entirely responsible for any delay or expense caused by the rejection of cement which does not satisfy the special requrements.

36. The Portland cement mortar shall be composed of one part of Portland cement to two parts (one part) of sand, mixed together, turned over, and thoroughly incorporated with a sufficiency of water. It is to be made in small quantities from time to time as required, and must be used within one hour of mixing.

37. The Roman cement is to be of the very best quality, and obtained from an approved manufacturer. The raw stone shall be fine grained, and after being thoroughly burnt, shall be ground to a fine powder The finished cement must not weigh more than

78 lb. per striked bushel, or more than 70 lb. per trade bushel, and must be stored in air-tight drums or casks, and kept in a dry place in free air currents.

38. The Roman cement mortar shall be composed of one part of Roman cement and one part of sand, mixed together with a sufficiency of water and thoroughly compounded. Owing to the quick-setting property of the cement, the mortar must be mixed by an experienced workman close to the position at which it is required and used immediately. When once partially set, it must not be revived.

39. The selenitic cement is to be obtained from the patentees, and mixed and used in accordance with the printed instructions issued by them

40 The fireclay is to be of the best quality, and from the same manufacturer supplying the firebricks.

DAMP COURSES

41. The damp course is to be formed with stoneware (fireclay) perforated vitrified blocks ....in. by ....in., and of the several widths required for the respective walls. The blocks are to have ribbed surfaces and tongue and grooved joints.

42. The bituminous sheet damp course is to be obtained from .... and laid (in accordance with their instructions) by them (the contractor given due and reasonable notice, as arranged, when the walls are ready, so that there may be no delay).

WORKMANSHIP CLAUSES FOR GENERAL WORK

PRELIMINARY

43. All brickwork is to be set out and built of the respective dimensions, thicknesses, and heights shown on the drawings.

44. All bricks are to be well wetted before being laid. The tops of the walls where left off are to be well wetted before recommencing them, as often as the architect may deem necessary.

45. All joints are to be thoroughly flushed up as the work proceeds. The vertical joints in the heading courses of English bond are to receive special attention.

46. Carry up walls in a uniform manner, no one portion being raised more than 3 ft above another at one time. All perpends,

quoins, etc., to be kept strictly true and square, and the whole properly bonded together and levelled round at each floor.

47. No brickwork is to be carried on during frosty weather, unless with the written permission of the architect who will give special directions as to the manner in which the work is to be performed. All brickwork laid during the day shall (in seasons liable to frost) be properly covered up at night with felt, sacking, boards, or other approved non-conducting material. Should any brickwork, laid on the day previous to a frost, become affected or damaged through not being covered or properly protected as previously specified, or by reason of the exceptional severity of the weather, the architect, at his discretion, may require the whole or any part of such brickwork to be removed and reinstated by the contractor at his own expense.

BOND

48. Brickwork generally except facings (all brickwork) to be laid in English bond consisting of alternate courses of headers and stretchers. Snap headers will not be permitted, and bats only as closers.

49. All facings are to be executed in Flemish bond, consisting in each course of headers and stretchers alternately, to break joint accurately.

50. Cut indents in alternate courses of existing brickwork, and tooth and bond new brickwork to same in cement mortar.

51. Lay in walls, at intervals of four courses, a layer of 1½ in. stabbed hoop-iron to each 4½ in. of thickness of wall, lapped or hooked at all angles.

JOINTS AND POINTING

52 The height of four courses of bricks laid in mortar is not to exceed by more than one inch the height of the same bricks laid dry.

53. The exterior facings are to be pointed with a neat weather joint in cement (blue mortar) cut in top and bottom, a sample of which is to be approved.

54. The interior facings to cellars are to be pointed with a flush joint neatly struck with the point of the trowel.

55. The joints to gauged work are to be pointed with........ (time putty) (cement mortar).

56. The enamel and salt-glazed facings to be flush pointed in

Parian cement, tinted to color of the glaze, the white enamel-glazed facings to be flush pointed in Keen's cement.

57. All internal walls, excepting those otherwise described, to be left rough for plaster.

58. Rake out joints for and point to all flashings in cement and also all frames.

FOOTINGS AND PIERS

59. Footings to be formed to spread on each side of the walls, half the respective thickness of same at base, diminishing in regular 2¼ in. offsets to proper thickness of walls. The courses of footings are to be laid of headers where practicable.

60. All underpinning to be executed with approved hard bricks, laid in cement mortar, well grouted at every course, and carefully wedged up with slate, provided by the contractor.

61. Lay over the full thickness of all walls and piers at the levels shown on drawings the........ horizontal damp course.

62. The outside faces of vault walls, dry areas to have approved asphalt damp course, ½ in. thick, laid thereon from the level of horizontal damp course to top of walls, and continued over top of vaults, and turned up around coal or ventilating plates or pavement lights, as required, to make vaults thoroughly water-tight.

63. All isolated piers carrying weights, and elsewhere if described, to be built in pressed bricks laid in cement and grouted at every fourth course.

64. Build honeycomb (solid) fender walls on proper footings to ground floors where shown.

65. (*a*) Build up dry area wall as shown on drawings in cement mortar, arched over into main wall three inches below ground level.

(*b*) Build up dry area wall as shown on drawings in cement mortar. Bed and point stone cover (provided by "Mason"), as shown, in cement mortar.

WALLS GENERALLY

66. Build in, or cut, bed, and pin in, all sills, thresholds, steps, landings, corbels, ends of joists, etc., in cement, and point as required. Build in frames, bedded solid in reveals, where specified to be built in.

67. Brickwork to be well pinned and backed up to all stonework and terra-cotta, and cut and fitted to ends of all steel joists, girders, lintels, etc.

68. Build in brickwork where required, fixing blocks (provided by "concretor") for fixing carpenters' or other work.

69. Build half-brick walls, small piers between windows and elsewhere as directed, in cement mortar.

70. Build chases and reveals in walls to receive frames, pipes, light wiring, etc., as shown on drawings, or required.

71. Bed all plates, lintels, templates, cover stones, etc., in cement as required.

72. Neatly cut and fit all facings to stone or terra-cotta dressings, arches, etc., and execute all rough and fair cutting as required.

73. Leave horizontal chases in walls to receive concrete floors or build sailing courses as shown to support same.

74. Turn rough segmental relieving arches in cement over all lintels where practicable.

75. Oversail where possible to support concrete floors and projections and to receive plates.

76. Level up on top of all riveted girders with plain tiles and cement.

77. Build in................air bricks (provided by "terra-cotta and Faience worker") ("founder"), where shown on drawings, and form cranked air-ducts to them in the wall, rendered in cement and sand.

78. The panels intended for carving are to be executed in rubber brick, as shown on drawings, set in shellac.

79. All niches, panels, and other enrichments to be executed in ....as shown on drawings.

FIREPLACES, CHIMNEYS, ETC.

80. Build in over each fireplace opening a wrought iron bar, provided by "smith," turn rough brick segmental arch over same in two rings, and properly contract the opening, and form throats to flues as detailed.

81. Build all smoke and ventilation flues of full bore shown, graduate all bends and parget flues as the work proceeds, and carefully core same, leaving openings in face of chimney-breasts where required for coring, and afterwards pin up same and make good.

82. Line all flues shown circular on plan with........in. unglazed terra-cotta flue pipes, and provide all requisite bends, purpose made or otherwise.

83. Properly bond the withes and other brickwork of all flues.

84. Build all chimney stacks above roof line in cement mortar with selected pots set in same, and well flaunched up and weathered in cement, to detailed drawing, joints left open for pointing as other brickwork.

85. Rough render all chimney-backs, and also brickwork to flues where near woodwork, in cement.

86. Carefully set all stoves, provided by "founder," with brick in mortar backing, fix iron and wood mantels securely with iron cramps pinned in cement; set kitchener in accordance with instructions with firebrick flues, and provide all firelumps, fireclay, etc., required.

87. Carefully set, where shown on drawings, all flue plates and soot doors and frames, provided by "founder."

88. Set in brickwork, as described, with firebrick linings in fireclay to flues, furnace pan, including all ironwork, dampers, soot doors, etc., provided by "founder"; the top and front to be rendered with Portland cement and sand, in equal proportions, $\frac{3}{4}$ in. thick.

89. Turn half-brick trimmer arches in cement 18 in. wide and 12 in. longer at each end than the width of the openings to all fireplaces where there is no support underneath.

90. Bed and point hearthstones in cement mortar.

FACINGS

91. Face the whole of the........excepting where otherwise specified, with best selected stock bricks, uniform in color.

92. All arches occurring in stock brick facings to be segmental arches in second quality malms, axed and set in cement.

93. Face the elevations tinted..........on drawings with ....'s first quality........facing bricks, carefully executed in accordance with details of elevations. Build all moulded strings, cornices, angles, etc., in similar red bricks, with moulded stops as shown on details.

94. Turn over all basement openings in........elevations, plain segmental arches in........rings in cement. Turn over all other openings where shown in brick on........elevations, gauged arches in red rubbers, accurately and closely jointed. That elliptic arches over........floor openings on........elevations to have voussoirs of similar gauged rubbers, alternating with terra-cotta voussoirs, provided by "terra-cotta and Faience worker," and moulded to details.

95. Face the following portions of back elevations: the light area to............and also the walls of lavatories in vaults, with..............quality..............bricks in fine mortar.

96. Reveals and arches to windows and doorways occurring in glazed work are to have bull-nosed angles, also all projecting piers in lavatories to have ditto. Any squints, etc., to be in white glazed quoins to required angle.

97. Turn segmental arches in glazed half brick rings in cement over openings as shown on elevations.

SUNDRIES

98. Build 4½ in. (glazed brick) piers (in scullery), where shown on drawings, to support stoneware (stone) sink, and properly bed and point same in cement mortar.

99. Cope parapets where shown to have brick coping, with two courses of plain tiles bedded in cement to project 1½ in. from faces of wall, or.............. patent drip tiles, and brick on edge coping the thickness of wall bedded and pointed in cement mortar and ramped as required.

100. Cope parapets and other walls where shown with purpose made coping bricks the thickness of the wall, pattern No.........
..............'s list, bedded and pointed in cement mortar..

101. Bed and point stone copings, provided by "mason," in cement mortar with the joints joggled.

102. Cut and pin in ventilating flues where shown approved ventilators, provided by "ventilating engineer."

103. The contractor shall, before pointing, clean down all brick facings, and make good all putlog and other holes throughout the work as it proceeds, and point the same.

104. Cut away, etc., as required for other trades, and make good after same.

For Limewhiting, see "Painter's Specifications."

HOLLOW WALLS

105. Build up the hollow walls as shown on drawings in two thicknesses, the outer thickness to be 4½ in., the inner........in., with a 2½-in. cavity between, the thickness of the entire wall being ....in. Bond the two thicknesses together with........ wall ties placed at a distance apart of 3 ft. horizontally and 12 in. vertically. The cavity is to be kept clear of all rubbish or

mortar droppings by movable boards or other means. Leave openings at the base and clean out the cavity at completion, the openings afterwards to be bricked up uniform with surrounding work. The wall ties to be carefully laid and in no case to fall towards the inner thickness of the wall. Build into inner face of exterior thickness over all frames a piece of sheet lead, provided by "plumber," projecting 2 in. beyond each side of lintel and turned up 1½ in.

DAMP-PROOF WALLING

106. Build up the walls in two thicknesses, the outer thickness being 4½ in., the inner thickness..........in., with a ½-in. cavity between, the total thickness of the wall being..........in. The bricklayer is to leave the cavity face joints free of mortar for a depth of ½ in., the cavity being kept clear of mortar droppings with a movable plain board. At a height of every four courses fill up the cavity with..............building composition, prepared and used according to instructions.

RETAINING WALLS

107. The retaining wall to be carried up according to the detail drawing, to be built of..........bricks laid in cement mortar grouted at every fourth course, to have the exterior face battered, the inner face finished with (diminishing offsets) all as shown.

108. Build in where shown 3 in. land drain pipes to run through the entire thickness of the wall, cut bricks to fit, and make good around same in cement mortar.

FACTORY CHIMNEY SHAFT

For specification of Iron Cap, see "Founder." For Lightning Conductor, see "Electrician." For Painting Iron Cap, see "Painter and Decorator's Specifications."

109. The whole of the brickwork throughout, including footings, walls, arches, string courses, cornices, etc., is to be built and carried up in accordance with the drawings, and is to be of the various thicknesses, heights, etc., or other dimensions as shown thereon, finishing at the top length of........ft., which is to be........ft........in. in thickness and is to be set in cement mortar.

110. All brickwork, except where otherwise specified, is to be built in lime mortar and in old English bond.

All the walls are to be carried up uniformly all round, and no part is to be left more than 3 ft. lower than any other. Each course is to be carried up to a uniform level throughout, and the whole of the work is to be built true, and the perpends strictly kept.

111. Two arched openings are to be formed (........ft. by ....ft.) in the base of the shaft, as shown, for the connection of the main flues thereto. The semicircular arches over openings to be turned in three $4\frac{1}{2}$ rings of brickwork carefully bonded in mortar and lined with firebrick.

112. Form sunk panels in each side of the square pedestal base of the dimensions, and after the manner shown upon the drawings.

113. The brickwork is to be built with neat close joints not exceeding $\frac{1}{4}$ in. in thickness, and no four courses of bricks to rise more than 1 in. in addition to the height of the bricks laid dry.

The cross joints are to be put in solid throughout the whole width of the bricks and the wall joints flushed up solid, and grouted with every course.

The bricks for facing must be properly bonded in at each course with the brickwork as the work proceeds.

114. The contractor shall do all cutting required for forming openings, splays, miters, chases, circular work, indents, recesses and skewbacks, and shall make good all putlog and other holes throughout the work as it proceeds, and point the same.

115. The whole of the exterior brick facing is to be pointed with a neat flat joint, and is to be jointed.

The interior faces of walls are to be jointed with a neat flat and flush joint.

116. The........ft. by........ft. main flue entrance in the base of the shaft which is not required for immediate use is to be built up as shown on plan, with 14-in. brickwork, consisting externally of 9-in. ordinary bricks and $4\frac{1}{2}$ in. internal facing of firebrick properly bonded thereto.

117. Build in a 3-in. cast-iron pipe (water main strength), with a screw hexagonal cap and spanner through the brickwork in the position shown upon the plan, for the purpose of inserting testing apparatus, etc.

118. The........brick cornices to be constructed in the topmost........ft length of the shaft, are to be of depths and projections shown upon the plans. They are to be thoroughly

well bonded together and set in cement, and if considered necessary by the architect are to be further secured with metal cramps run in with lead.

119. In the topmost length of the shaft, and between the two projecting blue brick cornices above mentioned, five projecting ribs are to be formed of facing bricks on each side of the octagon, as shown on the drawings. These ribs are to be spaced $4\frac{1}{2}$ in. apart in the clear, are to be $4\frac{1}{2}$ in. in width on the face, to project 3 in. from the face of the shaft, and are to extend......ft. in length. They are to be properly corbelled out at the bottom, and finished at the top with splayed blue bricks. All to be set in Portland cement mortar.

120. The shaft is to be internally lined with firebrick from the level of the floor of the main flue at its entrance at the base of the shaft to a height of........ft. above floor of main flue. The firebrick lining is to be built circular, is to be $4\frac{1}{2}$ in. in thickness and is to have an internal diameter of........ft. throughout its height. An air space of $2\frac{1}{2}$ in. in width is to be maintained at the back of the firebrick lining, between it and the ordinary brickwork. At the upper extremity of the firebrick lining this air space is to be completely oversailed with firebricks bonded into the brickwork, and projecting as shown on the plan. The contractor must be very careful to keep the air space perfectly clear of mortar or rubbish of any kind. To permit of an air current between the lining and the brickwork, a sliding grid ventilator is to be built in each face of the base of the shaft, near the ground level and a corresponding grid without slides is to be built in each case of the shaft just under the out-sailing course at the top of the lining. All firebrick linings are to be built of the best ....purpose-made radius firebricks, well wetted before use, solidly and truly set with the closest possible joints, in pure fireclay cement. The firebrick lining is to be bonded or stayed at intervals as may be necessary for securing same by firebrick bonders into the ordinary brickwork.

BRICKWORK DURING FROST

122. The bricks to be used for brickwork during frost shall be kept under cover free from moisture or frost. They are to be taken out only in small quantities as required for use, and are not to be wetted previous to being laid.

123. The water, sand and lime for the mortar must similarly

be kept under cover, free from frost. The lime is to be ground unslaked lime, mixed with the sand in the proportion of one part of lime to two parts of sand. Where the temperature is under 26° Fahr. the proportions shall be one part of lime to one part of sand. The mortar shall be mixed in ashes having a temperature of not less than 34° Fahr. in small quantities as required and used immediately.

124. The brickwork is to be executed as rapidly as possible consistent with good workmanship, and the courses shall be immediately covered with sacking as the work proceeds.

125. If the temperature shows the presence of more than 12° of frost, i. e., a temperature less than 20° Fahr., the work shall be immediately stopped.

NOTE.—The following are for brickwork for other trades.

FOR "DRAINLAYER" (HOUSE DRAINAGE)

126. Construct the manholes to the sizes and depths shown on the drawings, all depths being calculated from the inverts of the main channels in the manholes. The manholes are not to be built until the pipes entering them, have been properly laid and jointed.

127. The walls to be built of the full dimensions shown on the drawings in selected hard stocks laid in cement mortar in English bond. (The interior face joints for a distance of......ft. above the benches are to be left rough as a key for the rendering.) All (other) joints to be thoroughly flushed up with cement mortar, and are to be neatly struck with the point of the trowel. Point in cement the (exposed) brickwork to interior faces of manholes.

NOTE.—Some architects prefer to have manholes in stock bricks rendered on the interior faces in cement and sand. If rendering is not desired leave out the words in brackets.

128. The walls to be built of the full thicknesses shown on the drawing, of good hard stocks, with interior facings of (enamel glazed) (salt glazed) bricks in cement mortar in English bond, the joints to be well flushed up, grouted at every fourth course, the brickwork to interior faces being pointed in pure cement and neatly struck with the point of the trowel.

129. To be built as other manholes, but in addition to have a small brick chamber constructed at the side. 14 in by 14 in. by 27 in. in the clear, as shown on drawings An aperture to be formed in the division walls, and to have a..........mica valve

built in as shown on drawings as near the top of the manhole as practicable.

130. A chamber is to be formed at one end of........manholes by turning an arch in two 4½- in. rings from side to side as shown on drawings. The height of such chamber from the invert of the main channel to be 6 ft.

131. A chamber is to be formed at one end of the........manhole by partially roofing over with a good stone cover or landing as shown on drawings. The height of such chamber from the invert of the main channel to the underside of the stone to be not less than 6 ft. or more than 6 ft. 2 in. as the courses of brickwork allow.

132. Build up the walls to the heights, lengths, and thicknesses shown on detail drawing (1 stock 2. blue) bricks laid in cement mortar (1. the interior face joints left rough for rendering) (2. grouted in at every course and the joints being neatly struck with the point of the trowel). Form an aperature in division wall 9 in. by 12 in. as shown. Build in stone cover to aperture, stone templates under R. S. joists, hooks for grating chains, etc., as shown on detail. Secure grating channel to walls of filter chamber with holdfasts driven 6 in. into the brickwork. (1. The whole of the interior faces of tank and filter to be rendered and smoothly troweled in cement and sand ¾-in. thick.)

133. Build in the ends of all pipes at the heights and levels shown on the drawings, or as directed by the architect during the construction of the manholes, rain water tank, and filter etc. Build in step-irons at a height of every four courses of brickwork where shown on plan.

134. All drainpipes passing through manhole, R. W. tanks, filter, or other walls or foundations are to have arched openings formed for them so that they can be withdrawn without cutting and to prevent fractures from settlements.

135. The entrances to manholes, R. W. tanks, filter, etc., are to be corbeled over to the necessary openings for covers, as shown on drawings.

136. The walls to be 9 in. in thickness, built of stock bricks, laid in cement mortar or English bond. The interior face joints of brickwork to be left rough for rendering. The walls to be carried up perpendicularly for flat stone cover.

137. Bed and point all stone covers and landings to manholes in cement mortar bed and point stone covers to cleaning and

inspection eyes, inspection chambers and all movable covers in lias lime mortar.

138. Bed and point all iron cover frames to manholes, R. W. tanks, inspection chambers, lamp holes, etc., where shown on drawings, in cement mortar.

DRAINAGE

139. At the points shown build inspection chambers (or catch-pits),........ft. by........ft. internal diameter, in solid 9-in. stock brick, in cement mortar according to detail, the inlet and outlet pipes being built in as directed.

140. Build up face wall at outfall in good hard stocks, 9 in. in thickness, laid in cement mortar. Build in over the drain mouth close iron grating provided by "smith." The last pipe to be built in to slope slightly downwards and a little projecting in order that the effluent may discharge clear of the face of the wall, all according to detail.

FOR "MECHANICAL ENGINEER"

141. Build the engine bed in stock brickwork, and bed on stone cover supplied by "mason."

142. Build for and set the boilers................according to detail drawing in stock and firebrick.

143. The boiler to be set on fireclay seating blocks, 12 in. long, separated from boiler by wrought iron strips.

144. Line the flues with 4½-in. firebrick and finish against side of boiler with 9 in. by 9 in. quadrant fireblocks.

145. The seating at front end of boiler to be faced out with white enamel glazed brick in fine mortar, and neatly cut to same.

146. Line the blow-off pit with white glazed brick as above, with firebrick bottom. Build in iron drain pipe and bed stone cover supplied by "mason."

147. Form main flue under boilers........ft. wide, carry through wall........ft. by........ft. The arched flue to chimney to be........ft. wide and........to crown in 9. in. stock brickwork with 4½-in. firebrick lining.

148. Build manhole to ditto........ft. by........ft. in 9-in. brickwork. Wall up the opening to flue with straight jointed bricks, so as to be removed when required and form sump in ditto.

149. Cover in boiler side and flues with stone flags supplied by "mason."

STONEMASONS' GUIDE

PART II

MASONS' WORK

INTRODUCTION

A mason, properly speaking, means a builder, which is evident from the connection between the French words maçon, a mason; maison, a house, and maisonner, to build houses; but in America it is customary to look upon a mason and a stone mason as one and the same, a builder in bricks being always called a bricklayer. In Ireland the term masonry is specially applied to stone-walling, as distinguished from the cut stonework used in dressings and other work of a superior description.

In this country masonry is the art of building in stone in a similar manner to that of brick, with the exception that brickwork is carried out with uniform sized blocks, thus admitting of a number of definite systems of laying the bricks; whereas in stone, owing to the expense in working the material, the face stones only are squared, and the interior or hearting is filled up with smaller stones roughly fitted with a hammer. The stones are in the great majority of cases of varying dimensions, thereby making it a matter of great skill to obtain a proper bond in the work; and owing to the irregular shape of the material the walls have to be made considerably thicker than walls of the same height in brick, with the exception where the walls are built of coursed stones properly squared, in which

case the thickness may be even less than that of brick walls.

The great dimensions in which stone may be obtained, lends itself to a much greater degree than bricks for buildings of architectural pretensions, rendering it possible to have cornices and corbelled work of great projection, which is impossible in brickwork.

TECHNICAL TERMS

The following is a list, and also an explanation, of some terms used in stonework:

Bond, Lap, and Course.—These terms have the same meaning as given under brickwork.

Through Stones.—Stones which extend through the entire thickness of walls to tie or bond them. These are objectionable, as damp is more likely to show on the interior of walls where the continuity of the material is uninterrupted.

Headers.—The name applied to stones, the lengths of which are ⅔ to ¾ thickness of the wall, laid transversely.

Bonders.—These may be either "throughs" or "headers."

Grout.—This is a thin mortar, which is poured over the stones when brought up to a level surface, to fill up any interstices between the stones in the hearting of walls or other positions as necessity requires.

Spalls or Shivers.—These are broken chips of stone, worked off in the dressing.

Weathering.—The top face of a stone worked to a plane surface inclined to the horizontal for the purpose of throwing off the water is said to be weathered, as in sills, cornices, etc.

Footings.—The object of footings is the same as in brick walls. Stone footings should be large, rectangular, through stone blocks. Square stones in plan are not so good as oblong. All stones in the same course must be of the same height, but all courses need not necessarily be of the same depth. The breadth of set-offs need not exceed 3 or 4 in.

If the expense of stone is an objection, footings may be made of bricks or beds of concrete of sufficient depth. See chapters on Foundation and on Brickwork.

Bed Surface.—The bed surface must be worked in one plane surface. Masons, to form thin joints, often make the beds hollow. This is bad, as it is liable to spall; all the pressure will be thrown on the outer part, which is liable to spall the edge of the stone.

Galleting.—The term given when small pebbles are pressed into the face joints of rubble walls to preserve the mortar and to give a pleasing effect.

Dressings.—Stones are said to be dressed when their faces are brought to a fair surface; but cut or prepared stones used as finishings to quoins, window and door openings, are described as dressings.

Quoins.—In rubble and inferior stone walls, quoins are built of good blocks of ashlar stone to give strength to the wall. These are sometimes worked to give a pleasing effect, and where hammer dressed and chamfered are said to be rusticated. They are, at times, merely built with a rough or quarry face, only having the four face edges of each stone lying in one plane.

Window and Door Jambs.—For purposes of strength these should be of cut stone, attention being given that each course is securely bonded. For that reason

it would not be advisable to build them of rubble.

Stoncheons.—The stones forming the inside angle of the jamb of a door or window opening. These are often cast in concrete to effect a saving in labor.

Sills.—These are the lower horizontal members of openings; those in stone are usually of one length, being pinned in cement to both sides of the opening. They should be fixed after the carcass of a building has been finished, and any settlement that was likely to occur through a number of wet mortar joints has taken place. They may be plain and square, as for door sills, or sunk, weathered, moulded with drip and with properly formed stools, and grooved for metal water bar, or moulded, grooved and weathered.

Corbel.—A stone projecting from a wall to support a projecting feature.

Skew Corbel.—Is a projecting stone at the lowest part of the triangular portion of the gable end of a wall supporting the starting piece of coping, and resisting the sliding tendency of the latter. The skew corbels are often tied into the wall by long iron cramps.

Kneeler or Skewput.—This is a long stone, tailing well into the gable wall, and resists the sliding tendency of the coping.

Saddle or Apex Stone.—The highest stone of a gable end, cut to form the termination of two adjacent inclined surfaces.

Lacing Course.—Owing to the absence of bond in some walls, courses of bricks, three deep, are inserted at intervals, to give strength to the wall and bring it to a level surface. Sometimes the name is applied to a horizontal band of stone placed in rubble or rough walls to form a longitudinal tie.

String Courses.—Horizontal bands of stone sometimes moulded and projecting, often carried below windows to accentuate the horizontal divisions of a building.

Plinth.—A horizontal projecting course or courses built at the base of a wall. These are to protect the wall, and are often built in hard hammer-dressed stones.

Cornices.—The moulded course of masonry crowning buildings, generally having a large projection to throw off the rain.

Saddled or Water Joint.—To protect the joints of cornices and other exposed horizontal surfaces of masonry, the sinking is sometimes stopped before the joint and weathered off. Any water passing down the weathered surface is guided away from the joint. The expense of this joint often prohibits its use.

Blocking Course.—A course of stones erected to make a termination to the cornice, the object being to gain extra weight to tail down the cornice, and to form a parapet.

Coping.—The highest and covering course of masonry, forming a waterproof top, to preserve the interior of wall from wet, which in frosty weather might burst the wall. Fig. 52, B. shows a coping flat on the top surface, which should be used only for inclined surfaces, as on a gable, or in sheltered positions. Saddle-back is the name applied when the upper surface is weathered both ways; and segmental, when the section of copings shows the upper surface to be a part of a circle.

Rebated Joints.—These joints are used for stone roofs and copings to obtain weather-tight joints. There are two kinds: 1, when both stones are rebated; 2, when the upper stone only is rebated. In the first case the stones are of the same thickness throughout,

their upper surface being level when the joint is made. In the second case the stones are thicker at the bottom edges than at the top, the bottom edge having a rebate taken out equal to the thickness of the upper edge of the stone below it, over which it fits. The part that laps over should not be less than ¾ in. thick. The upper surfaces or beds of the stones should be level.

Throatings.—Grooves on the under surfaces of copings, sills, string courses, etc., acting as drips for any water that would otherwise trickle down and disfigure the walls.

Templates.—Slabs of stone placed under the end of a beam or girder to distribute the weight over a greater area.

Gable Details.—The tops of stone walls are protected by coping, and these, where placed on steep gables, need support at their lower ends and at intervals; this may be done by constructing a shoulder at the foot, or by the use of skew corbels. The intermediate supports are obtained by kneelers, which consist of stones having a part worked as a coping, the remainder tailing well into the wall.

Corbie Step Gables.—A common method of finishing gables is by constructing a number of steps formed of some hard stone squared, the top surfaces being slightly weathered and known as corbie or crow-step gabling.

Gablets.—Many skew corbels are constructed with a small gablet, which gives extra weight to the skew corbel, thus rendering it more efficient for resisting the outward thrust of the coping stones. The apex stones are often treated in a similar manner.

Corbel-table.—A system of corbeling supporting a parapet, often forming an architectural feature.

Finial.—The aspiring ornament of an apex stone often richly foliated.

Parapet.—The fence wall in front of the gutter at the eaves of a roof. The castellated parapet is formed by a number of embrasures similar to the parapets used in ancient military buildings, much used in the later Gothic work as an ornamental feature.

Diaper Work.—Is the name given to bands, surfaces and panels in the stone work formed by square stones and similar squares, filled in with brick or flint work, giving a checkered appearance. The term is also applied to any ornament arranged in squares upon the surface of ashlar masonry.

Tympanum.—The masonry filling in between the relieving arch and the head of a door or window. Advantage is often taken of this to form a ground for carved ornament.

Gargoyle.—Is a stone water-spout, employed in buildings of Gothic character to carry off the rain from the gutters. These project sufficiently far to throw the water clear of the building. At present down pipes are employed, but the gargoyle is often retained as an overflow in lieu of a warning pipe.

Tailing Irons.—These are formed of H, L, or T irons for holding down the ends of corbels in oriel windows.

Lintels.—Wide spans requiring to be bridged by stone lintels (as is the case in the trabeated styles of architecture) are often of a greater dimension than can be conveniently obtained in one stone, in which case the lintel is built up in one of two ways:

(1) By an arched construction. The sloping joints in this method are considered objectionable by some, altering as it does the principle of the construction from the beam to the arch, the number of small pieces

detracting from the general effect. Vertical joints are preferred to inclined. The arched principle, with vertical jointed voussoirs, may be carried out by forming the joint vertically on and about 4 in. below the face and the remainder to the back, or, if seen on both sides, in the center of the lintel. The stone cut thus form voussoirs of an inch.

(2) The method now most usually adopted is to build the lintel up of a number of pieces with vertical joints and in two thicknesses, the front and back portion being made to envelop the flanges of a steel girder, which bridges the whole span and takes its bearing on the columns. The back and front pieces are connected on the soffit, and the upper surface by small copper cramps, the latter being bedded in cement mixed with dust from the stones to be united. The hole soffit is finally rubbed over with a piece of stone similar to the lintels, to render the joint as nearly as possible invisible. Care must be taken to protect the iron girder from the danger of oxidation by applying one of the preservative processes employed for iron and steel.

The stone entablatures built over shop fronts are formed in this way, but have the stone on one side only of the girder, being connected to the same with cramps.

The masonry above stone lintels should be disposed to throw, as much as possible, the weight of the superimposed walling on to the supports, and not unnecessarily stress the lintel.

Labors.—The following are the chief labors adopted in preparing stone work:

Half-Sawing.—The surface left by the saw; half the cost of the sawing being charged to each part of the separated stone.

Self-faced.—The term applied to the quarry face, or the surface formed when the stone is detached from the mass in the quarry; also the surfaces formed when a stone is split in two.

Scabbling or Scappling.—That is, taking off the irregular angles of stone; is usually done at the quarry, and is then said to be quarry pitched, hammer faced or hammer blocked; when used with such faces the stone is called rock or rustic work.

Hammer Dressing.—Roughest description of work after scabbling.

Chisel Drafted Margin.—To insure good fitting joints in hammer faced stones, a true surface about an inch wide is cut with a chisel, forming a margin on the face of stone.

Plain Work.—This is divided, for purposes of valuation, into half plain and plain work. The former term is used when the surface of the stone has been brought to an approximately true surface, either by the saw or with the chisel. Plain work is the term adopted for surfaces that have been taken accurately out of winding with the chisel. Half plain is usually placed upon the bed and side joints of stones in ashlar work and plain work on the face.

Rubbed Work.—This labor consists in rubbing the surfaces of stones until perfectly regular, and as smooth as possible. The work is accomplished by rubbing a piece of stone with a second piece. During the first stages of the process, water and sand are added, gradually reducing the quantity of sand up to the finish. Large quantities of stones are rubbed by means of large revolving iron discs, on which the stones are placed, and kept from revolving with the disc by means of stationary timbers fixed a few inches

above and across the table. Water and sand are added to accelerate the process. Only plane surfaces can be rubbed in this way.

Polishing.—Marbles, after the rubbed operation, are brought to a still smoother surface by being well rubbed with flannel and a paste of beeswax and turpentine or putty. The polishing of granite has been described elsewhere.

Boasted or Droved Work.—This consists in making a number of parallel chisel marks across the surface of the stone by means of a chisel termed a boaster, which has an edge about 2½ in. in width. In this labor, the chisel marks are not kept in continuous rows across the whole width of the stone.

Tooled Work.—This labor is a superior form of the above, care being taken to keep the chisel marks in continuous lines across the width of the stone. The object of this and the preceding is to increase the effect of large plane surfaces by adding a number of shadows and high lights. This labor is sometimes known as scabbled work.

Axed Work.—Axed work and tooled work are similar labors. The axe is employed for hard stones, such as granite, but the mallet and chisel for soft stones, being more expeditious.

The method of preparing the hard stones after being detached from their beds in the quarry is as follows: The stones are roughly squared with the spall hammer; the beds are then prepared by sinking a chisel draught about the four edges of the bed under operation, the opposite draughts being out of winding, and the four draughts in the same plane surface; the portions projecting beyond the draught are then taken off with the pick. After the pick the surface is wrought with the

axe, the latter being worked vertically downward upon the surface, and taken from one side of the stone to the other, and making a number of parallel incisions or bats; the axe is worked in successive rows across the stone, the incisions made being kept continuous across the surface. In axed work there are about four incisions to the inch. This labor is used for the beds of stones for thresholds and curbstones, and in this state the pick marks are easily discernible. Fine axed work is a finer description of axed work, and is accomplished with a much lighter axe having a finer edge. In fine axed work there would be eight incisions to the inch.

Furrowed Work.—This labor, used to accentuate quoins, consists in sinking a draught about the four sides of the face of a stone, leaving the central portion projecting about ⅜ of an inch, in which a number of vertical grooves about ⅜ in. wide are sunk.

Combed or Dragged Work.—This is a labor employed to work off all irregularities on the surfaces of soft stones. The drag or comb is the implement used. It consists of a piece of steel with a number of teeth like those of a saw. This is drawn over the surface of the stone in all directions, making it approximately smooth.

Vermiculated Work.—This labor is placed chiefly on quoin stones to give effect. The process is as follows: A margin of about ¾ in. is marked about the edge of the stone, and in the surface enclosed by the margin a number of irregularly shaped sinkings are made. The latter have a margin of a constant width of about ⅜ in. between them. The sinkings are made about ¼ in. in depth. The sunk surface is punched with a pointed tool to give it a rough pockmarked appearance.

Pointed Work.—The bed and side joint of stones are

often worked up to an approximately true surface by means of a pointed tool or punch. This labor is often employed to give a bold appearance to quoin and plinth stones, and where so used it usually has a chisel-draughted margin about the perimeter.

Moulded Work.—Mouldings of various profiles are worked upon stones for ornamental effect. Mouldings are worked by hand as well as by machine. In the former case, the profile of the moulding is marked on the two ends of the stone to be treated by means of a point drawn about the edge of a zinc mould, cut to the shape of the profile. A draught is then sunk in the two ends to the shape of the required profile. The superfluous stuff is then cut away with the chisel, the surface between the two draughts being tested for accuracy by means of straight-edges. The machines for moulded work somewhat resemble the planing machines for metal work. The stone is fixed to a moving table. The latter has imparted to it a reciprocating rectilinear motion, pressing against a fixed cutter of the shape of required profile, or some member of it. The cutter is moved near to the stone after each journey, thus gradually removing the superfluous stuff till the profile is completed. Moulded work is, strictly speaking, the name given to profiles formed with a change of curvature, and therefore should not be applied to cylindrical sections, such as columns.

The weathering properties of stones moulded by hand labor are considered by some far superior to those worked by machinery, as in the latter method the moulding irons, being driven continuously, become heated and partially calcine the surfaces of the stones, thus rendering it peculiarly susceptible to atmospheric deterioration.

Moulded Work Circular.—This term is given to mouldings stuck upon circular or curved surfaces in plan or elevation.

Sunk Work.—This term is applied to the labor of making any surface below that originally formed, such as chamfers, wide grooves, the sloping surfaces of sills, etc. If the surface is rough, it is known as half-sunk; if smooth, sunk, and any other labor applied must be added, such as sunk, rubbed, etc.

Circular Work.—Labor put upon the surface of any convex prismatic body, such as the parallel shaft of a column or large moulding, is termed circular work.

Circular Sunk Work.—Labor put upon the surface of any concave prismatic body, such as a large hollow moulding, or the soffit of an arch, is termed circular sunk work.

Circular Circular Work.—The labor placed upon columns with entases, spherical or domical work.

Circular Circular Sunk.—The labor worked upon the interior concave surfaces of domes, etc.

Internal Miters.—The name given to the intersections of two mouldings making an angle less than 180 degrees.

External Miters.—The name given to the intersection of two mouldings making an angle greater than 180 degrees.

Returned Mitered and Stopped.—The name given to a moulding returned in itself, and stopping against an intersecting surface.

Long and Short Work.—This work is often used for quoins and dressings in rubble walls, and is especially noticeable in old Saxon work. It consists in placing alternately a flat slab, which serves as a bonder, and a long stone approximately small and square in section.

This arrangement in modern work is sometimes known as block and start work.

Stone Walling.—Is divided under the following headings: 1, Rubble; 2, Block in Course; 3, Ashlar. Illustrations of these various kinds of walling will be shown later on.

Rubble walls are those built of thinly bedded stone, generally under 9 in. in depth, of irregular shapes as in random rubble or squared as in coursed rubble.

Block in course is composed of squared stones usually larger than coursed rubble, and under 12 in. in depth.

Ashlar is the name given to stones, from 12 to 18 in. deep, dressed with a scabbling hammer, or sawed to blocks of given dimensions and carefully worked to obtain fine joints.

The length of a soft stone for resisting pressure should not exceed three times its depth; the breadth from one-and-a-half to twice its depth; the length in harder stones four to five times its depth, and breadth three times its depth.

Random Rubble.—The name given to walling built of stones that are not squared, but roughly fitted with a waller's hammer.

Random Rubble Set Dry.—In the stone districts boundary walls are built of rubble set without mortar. The top is built of heavy stones, which are usually bedded in earth, to prevent slight movement.

Uncoursed Random Rubble Set in Mortar.—In these the stones are used as they come from the quarry, care being taken to obtain them as uniform as possible, and roughly fitting with the waller's hammer; one bond stone is used in every super yard on face; any openings between stones to be pinned in with spalls. If

good mortar is used, walls built of random rubble should be made one-third thicker than the thickness necessary for brick walls.

Random Rubble Built in Courses.—This consists of stones forming horizontal beds at intervals of 12 to 18 in., every stone being bedded in mortar. The object of coursing is to insure that there shall be no continuous vertical joints. To save expense in bedding each stone in mortar, masons bed only the stones on faces of wall, and at these levels pour a pail of thin mortar, called grout, to fill up any cross joints between stones, taking care that the hearting stones are properly interlocked.

Uncoursed Squared or Snecked Rubble.—Stones roughly squared and hammer or axe faced, the vertical depth of the stones usually being less than 9 in; to prevent continuous long horizontal joints, small stones, termed snecks, are placed at intervals adjacent to a large stone, the beds of both being level and thereby commencing a horizontal joint at another level.

Squared Rubble Built in Courses.—Squared rubble is brought up to level beds with dressed quoins. The coursing is to prevent continuous vertical joints. It is sometimes known as irregular coursed rubble, as the courses need not all be of a uniform depth.

Regular Coursed Rubble.—In this kind of work all stones in one course are squared to the same height, usually varying from 4 in. to 9 in., and are generally obtained from thin but regular beds of stone.

Block in Course is the name applied to stone walling, chiefly used by engineers in embankment walls, harbor walls, etc., where strength and durability are required. The stones are all squared and brought to good fair joints, the faces usually being hammer-dressed. Block

in course closely resembles coursed rubble, or ashlar, according to the quality of the work put upon it.

Ashlar.—Ashlar is the name applied to stones that are carefully worked, and are usually over 12 in. in depth.

As the expense would be too costly to have walls built entirely of ashlar, they are constructed to have ashlar facing and rubble backing, or ashlar facing and brick backing, but, as the backing would have a greater number of joints than the ashlar, the backing should be built in cement mortar, and brought to a level at every bed joint of the ashlar, to insure equality of settlement.

The ashlar facing may be plain, rebated, or chamfered, and looks best when laid similar to Flemish bond in brickwork.

JOINTS

In arranging the joints of masonry the following general principles should be observed:

1. All the bed joints must be arranged at right angles to the pressure coming upon them.

2. Joints should be arranged to prevent any members, such as sills, being under a cross-stress.

3. The joint should be arranged so as to leave no acute angles on either of the pieces joined.

The first condition applies to all kinds of masonry. It is necessary to prevent any sliding tendency taking place between the stones.

The second condition applies chiefly to sills in window openings. These, if in one piece, and built into the piers at each side of the opening, are often subjected to a cross-stress, owing to the settlement being greater under the piers than beneath the window open-

ings. This danger occurs more frequently in openings in the lowest story, and the effect of it is to break the sill. In brickwork, this defect is remedied by fixing the sill after the whole of the brickwork has been erected and the settlement taken place; but in stonework, and under conditions where the sill must be fixed as the building proceeds, the breaking of the sill may be prevented by having a vertical joint in the line of the face of the reveal.

If there are any heavy mullions down which pressure may be transmitted, the same precaution must be taken with the sill; but if light mullions occur, the sill may be taken continuously through. In such cases no joint in the sill should occur under the mullions.

The third condition applies chiefly to the joints in tracery work, and any exposed joints in any other work. Stone being a granular material, anything approaching an acute angle is liable to weather badly; therefore in any tracery work having several bars intersecting, a stone must be arranged, to contain the intersections and a short length of each bar, and the joints should be (*a*) at right angles to the directions of the abutting bars if straight, or (*b*) in the directions of a normal to any adjacent curved bar. This not only prevents any acute angles occurring, as would be the case if the joints were made along the line of intersection of the moulding, but also insures a better finish, as the intersection line can be carved more neatly with the chisel, and is more lasting than would be the case if a mortar joint occurred along the above line. In no case, either in tracery, string courses, or other mouldings, should a joint occur at any miter line.

Joints.—These may be classified as follows:

1. To resist compression, such as the square joint,

the surface of which is arranged normal to the pressure.

2. To resist tension, cramps, lead plugs and bolts.

3. To resist sliding or displacement, joggle, joints, tabling dowels and pebbles.

Joints to Resist Compression.—Joints in stone under a compressional stress have plane abutting surfaces normal to the stress

Joints to Resist Tension.—The texture of stone is unsuited to form tensional connections. Where there is any tensional stress the joints are best held together by metal connections.

Cramps.—Metal cramps are used to bind work together, and are particularly adapted for positions in which there is a tendency for the stones to come apart, such as in copings covering a gable, or in face stones of no great depth, or cornices and projecting string courses to tie them to the body of the wall. The cramps are made from thin pieces of metal of varying lengths and sectional area according to the work, turned down about 1½ in. at each end. The ends are made rough and inserted into dovetailed-shaped mortises, and the body in a chase made to receive them in the stones to be connected. The cramps are usually prepared from either wrought iron, copper, or bronze. If wrought iron is used, it is usually subjected to some preservative process, such as tarring and sanding or galvanizing, to prevent oxidation. Iron is useful on account of its great tensile strength. Copper is valued for its non-corrosive properties under ordinary conditions, and its tensile strength, which is not much less than wrought iron; it is, however, comparatively soft. Bronze possesses all the properties of copper necessary for cramps, and in addition is much harder, and therefore better.

The best bedding materials are Portland cement, sulphur and sand, asphalt and lead. Care should be taken to completely envelop the cramp in the bedding materials. Stones are also connected by slate cramps set in cement.

Lead Plugs.—Stones may be connected together by means of lead in the following manner: Dovetailed-shaped mortices are made to correspond in the side joints of two adjacent stones, into which, when placed in position, molten lead is poured, and when cool is caulked, thus completely filling the mortises and connecting the pieces.

Bolts.—Stone pinnacles, finials, and similar members, where built of several stones, are usually connected together with iron bolts passing through all of them and binding down to some more stable portion of the work. Cornices with a great projection are secured by long iron bolts, termed anchor bolts, carried well down into the body of the work, and at their lower ends passing through large iron plates termed anchor plates.

Rag Bolts.—Are employed to secure ironwork to stone. The ends of the bolts are often fixed by having the end that is let into the stone jagged, and run with lead, or sulphur and sand, the mortise being dovetailed-shaped to secure it from any upward pressure.

Where there is any probability of a great upward stress a hole is drilled right through the stone and a bolt supplied with a washer passed through in the ordinary manner.

Joints to Resist Sliding.—The following are those most used:

Joggles.—A joggle is a form of joint in which a portion of the side joint of one stone is cut to form a projection, and a corresponding sinking is made in

the side of the adjacent stone for the reception of the projection. It is chiefly used in landings to prevent any movement between the stones joined and so retain a level surface between them, and also to assist in distributing any weight over every stone in the landing.

Tabling Joints.—This is a form of joint that has been used to prevent lateral motion in the stones of a wall subjected to lateral pressure, such as in a sea-wall. It consists of a joggle joint in the bed joints, the projection in this case being about 1½ in. in depth and a third of the breadth of the stone in width. This kind of joint is rarely used now, owing to the great expense in forming it, it being superseded for sea-walls by huge blocks of concrete cast on or near the spot, of a weight sufficient to resist any pressure likely to be brought to bear on them, and usually under other conditions by long slate joggles placed in a space to receive them in the bed joint at the junction of side joints of two stones and the top bed joint of another.

Cement Joggles.—These are generally used in the side joints of the top courses of masonry to prevent lateral movement in them, and consist of a V-shaped sinking in the side joint of each adjacent stone in the same course.

Dowels.—Doweling is another method of obtaining the same result as joggling or tabling. The dowels consist usually of pieces of hard stone or slate about 1 in. square in section, and varying from about 2 in. to 5 in. in length, slightly tapering from the center towards the two ends, being sunk and set in cement in corresponding mortises in the adjacent stones. They are used in both the side and bed joints. They are generally employed in the top courses of masonry

where the weight on or of the individual stones is not great. The united mass thus formed from the collected stones renders any movement impossible under normal conditions.

Pebbles.—Small pebbles, owing to the ease with which they may be fitted, were formerly employed in the joints of stones to prevent sliding. They are now in most work displaced by slate dowels or joggles. The pebbles are still sometimes used for small work.

TOOLS AND APPLIANCES USED IN CUTTING AND BUILDING STONEWORK

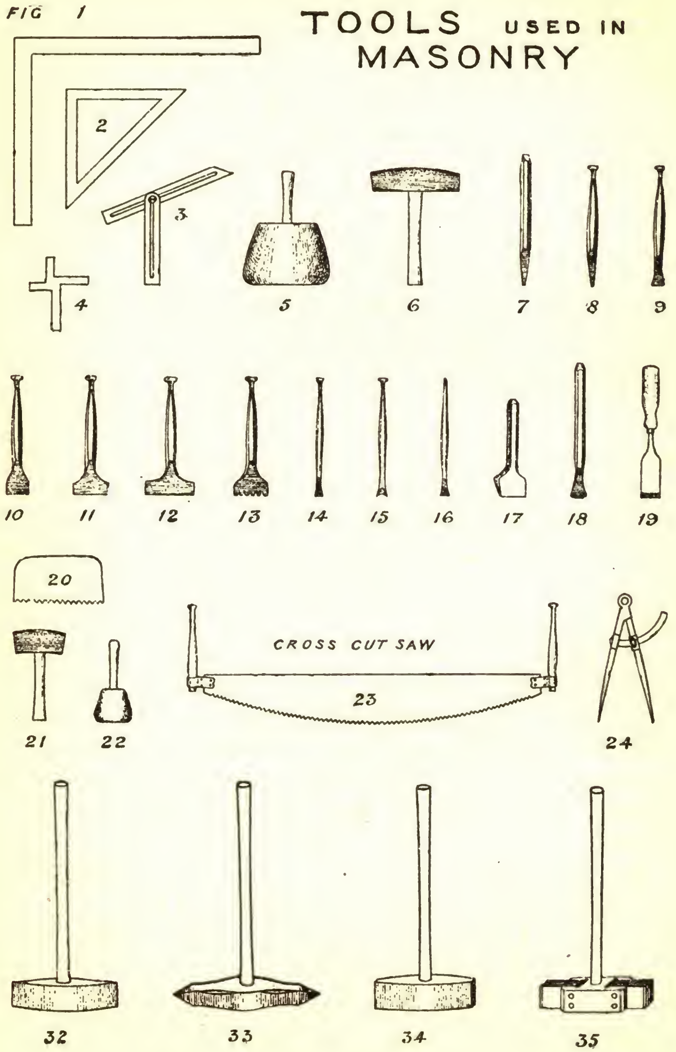
The tools used by the mason are many and varied, as different tools are required for different styles of work, and even where the same style of work is being wrought, but being made of softer or harder materials, other sets of tools will be required. Marble and the softer stones are worked with tools that are very much different from those used in working granite or the harder stones.

The following tools and appliances are those mostly used at the present time by operative masons:

Fig. 1. The square is of various sizes, and generally made of steel plate about one-eighth of an inch thick; the edges are parallel and at right angles to each other.

It is important that the square should be true, as the accuracy of the work depends entirely upon it, and for this reason it should be frequently tested for correctness.

Fig. 2. The set square is of several sizes, and made of iron, brass, or zinc plate; it contains a right angle


TOOLS USED IN MASONRY
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CROSS CUT SAW
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and two angles of forty-five degrees, and is used chiefly for miters, and setting out on bed of work.

Fig. 3. The bevel, or shift stock, made of iron or brass, and used for sinkings, bevels, etc.

Fig. 4. A small tee square of unequal sides, and with right angles, used for sinkings, etc.

Fig. 5. Mallet of beech, or other hard wood, of various sizes, for striking the cutting tools.

Fig. 6. Hand hammer of steel, about five pounds in weight, used principally with punch for removing waste, and in very hard-grit stones. It is used also with hammer-headed chisels.

Fig. 7. The punch; the cutting edge of this tool is about a quarter of an inch wide, and chisel-pointed. It is used with the hammer for removing all superfluous waste.

Fig. 8. The point, with edge similar to punch, is used with mallet, generally for hard-grit or lime stones, and for reducing the irregularities left from punch, leaving the stone in narrow ridges and furrows close down to face.

Fig. 9. Chisels, of various widths, from ¼ in. to 1½ in. wide, used for mouldings, fillets, sinkings, etc.

Figs. 10 and 11. Boasters, from 1½ in. to 3 in. wide, used for dressing stones down to smooth faces, and cleaning or finishing mouldings, etc.

Fig. 12. Broad-tool, about 4 in. wide, used for tooling.

Fig. 13. Claw-tool. These are of various sizes, the teeth being cut coarse or fine to suit the texture of the stone. For hard lime stones the teeth at point are about ⅛ in. wide, and for softer stones from ¼ to ⅜ in. wide. The claw tool is used after the punch or point, dressing down the ridges still closer to finished face.

Figs. 14 and 15. Small chisels, of various sizes, for carving, letter-cutting, etc.

Fig. 16. Small chisels, called "splitters," of various sizes; the heads are concave, or cup-headed, as in sketch, Fig. 38. When used with an iron hammer, Fig. 21, they cut very smooth and sweet.

They are used mostly for marble work, carving, lettering, etc.

Fig. 17. Pitching tool; this has a beveled instead of a cutting edge, and is used with the hammer, for pitching or knocking off the irregularities or waste lumps on stone.

Fig. 18. Jumper, chisel-pointed and slightly round-nosed; it is wider at cutting edge than the diameter of tool, so that it clears itself in cutting circular holes, for which it is used, chiefly in granite.

Fig. 19. Chisel for soft stone (this is a general term, and comprises varieties like marble or alabaster). The chisels have wood handles, and are similar to carpenters' "firmer chisels."

Fig. 20. Drags for soft stone, of best steel saw-plate, with coarse, middling, and fine teeth, called coarse, seconds, and fine drags. These are used by traversing the face of the stone in all directions and removing the saw and chisel marks, and finishing to any degree of smoothness required.

Fig. 21. Iron hammer, about three or four pounds weight, used with cup headed tools, for carving, lettering, etc.

Fig. 22. Dummy, of lead or zinc, about three or four pounds in weight, used for striking the soft stone

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NOTE—Numbers 8 and 15 are mallet headed tools, and must never be struck with the hammer, the heads being made to receive the blow of the mallet only.

tools; it is handier than the mallet, and at times more convenient to use.

Fig. 23. Cross-cut saw, of best steel plate, and of various sizes, for cutting soft stone blocks, scantling, etc.; the teeth are coarse, and broadly set for clearance. Two men are required in using it.

Fig. 24. Compasses, for setting-out work, etc.

Fig. 25. Shows sketch of a saw frame, for hand-sawing, which in practice requires some little skill in framing up to the various sizes.

The frame generally, for good working, should be about two feet longer inside than the length of stone to be sawed, so as to allow for draft.

The heads or ends of frame are made of 4×3 in. pine, tapered from near the top to $3\frac{1}{2} \times 2$ in. at the bottom, with a groove or slot for the saw 4 in. deep by $1\frac{1}{4}$ in. wide, the angles being rounded off or smoothed to make it easy for the hands.

The stretcher is a piece of pole about 3 in. in diameter, with iron ferrule at each end, varying in length. Packing pieces are used against the head at each end of stretcher as shown.

The couplings are in wrought iron, $\frac{1}{4}$ in. in diameter, of various lengths and shapes, as in sketch. These are tightened up with a union screw in the center, which keeps the saw taut, so that no difficulty is experienced in getting the saw frame to the required length.

The saw plate is of iron, about 4 in. wide by $\frac{1}{10}$ in. thick, with two holes punched through it, $\frac{3}{4}$ in. in diameter, at each end, for iron pins, which are inserted to keep the saw in position. The pins are 4 in. long, and have a small slot the thickness of the saw plate and $\frac{1}{8}$ in. deep, fixed with the groove towards the end

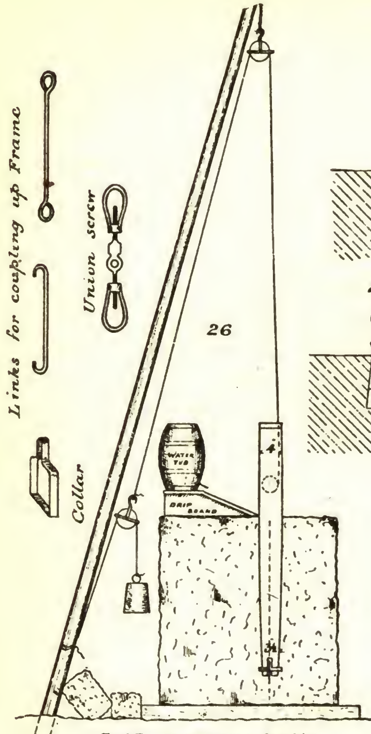
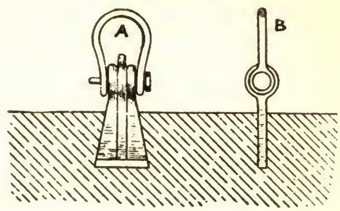


FIG 28



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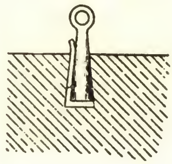

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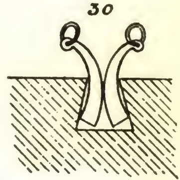

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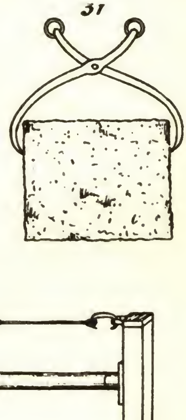
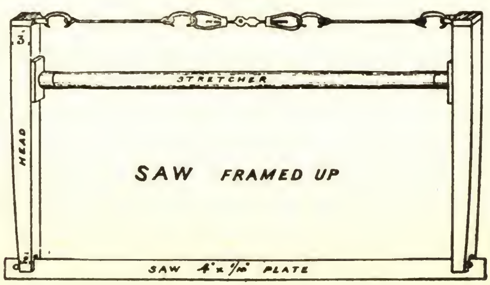


END VIEW OF SAW

FIG 25



of the saw; this enables the sawyer to keep the saw straight down the cut, by tapping either end of the pin, should the saw deviate from the vertical line. This slot in the pins is important, as the saw cannot be kept true without this arrangement. The pole, for carrying the saw frame, is from 16 to 20 ft. long and 3 or 4 in. diameter at bottom, and tapering towards the top; a crosspiece and chain is secured nearly at the top of pole to carry the pulley. The pole is kept in position by planting it in the ground, and a rough piece or two of stone is laid against it. The cords for carrying the saw frame are about ½ in. in diameter; small chains are sometimes used, but cords work more easily.

The cord is fastened round the stretcher and over the pulleys on top of the pole (which must be vertical to the cut), and then round hook of bottom pulley. The weight must be so adjusted as to allow the saw-frame to be the heavier by about eight or ten pounds; this, however, will depend greatly on the nature of the stone. The position of weight can be raised or lowered to suit the cut by shifting the cord at the bottom of the pole.

The drip board is of pine, as in sketch, and about 2 ft. long, with sloping side against the cut, and on this is placed the water tub; a small spigot is inserted in the bottom of the tub, and is adjusted to allow the water to trickle down the board, carrying with it the sand, which is also on the board, into the cut. To regulate the supply of water and sand, the sawyer uses a small rake with a long handle.

The line of cut for saw should be set out with a plumb rule or bob at each end of the block, and a V-shaped chase cut in to guide the sawyer in keeping to a true line.

The best sand for cutting is hard grit, washed through several sieves, all the coarse and fine being rejected, and the medium size only used. A bushel of this sand will cut about 12 ft. super of stone.

The saw is drawn backwards and forwards and the stone cut by the attrition of the saw-plate with the sand and water.

A good sawyer can cut by hand from 15 to 20 ft. super of sandstone in one day of ten hours.

On large jobs steam stone saw frames are used, in which, if necessary, from one to twenty cuts may be put in one block at the same time.

Fig. 27. Shows a method of coping or splitting a block of stone to a required size.

Begin by cutting a V chase on top and two sides of the block, as at *g*, *f*, *e*; directly under this place a wood skid, and on the top of the skid a long iron bar, which should bone with the line *gf*; or a punch driven in on each side, as at *e*, will do nearly as well. At extreme end place a short skid, as at *h*, and packed up to within an inch of the under side of the block. This is done to prevent the coped piece from breaking under by its own weight, as the fracture would not take the line of direction proposed, but would probably break away from *j* to *k* and spoil the block.

Sink wedge holes with the punch (at distances apart varying with the nature of the stone) to as fine a point as possible at the bottom of the hole, as in sketch, at *b*, so that the wedge will bite or hold when struck with the hammer. The apex of the wedge, which is of iron, is blunt pointed and about ¼ in. wide, so that it does not touch the bottom of the hole, or when struck it would jump out. The holes being cut, the wedges are inserted in each one; care must, however, be taken

to keep them upright, so that the cleavage takes the line of direction required. The wedges are now gently tapped with a heavy hammer, till all have got a hold; then harder blows are given in quick succession, and the fracture takes place.

a shows sketch of wedge, made of iron, and from 4 to 5 in. long and 1½ in. wide.

In coping or splitting granite, wedge holes are not cut as in stone, but circular holes are "jumped," 1 in. or 1¼ in. in diameter and about 5 in. deep, at distances apart varying with the obstinacy of the material, and plugs and feathers are inserted and driven in as for stone. The plug is of soft steel, and made tapering as at *c*.

The feathers are thin pieces of iron, concave in section, as shown at *c* 1. These are first put in the holes, the plugs are then driven in until they become tight, and a few sharp blows are all that is necessary to complete the process of splitting. *c* 1 is a plan of *c* to a larger size.

Fig. 28 shows a pair of iron lewises used in lifting worked stones for fixing. The lewis consists of a dovetail of three pieces, the two outer pieces being first inserted in the hole, and then the center piece, which acts as a key, and tightens up the dovetail; the shackle is next put on, and the bolt is passed through the whole.

Care must be taken to cut the hole to a dovetailed shape, and of the size of the lewis.

A is the front view and *B* is the side view, of the lewises.

Fig. 29. Shows an iron conical-shaped lewis plug, which is placed in a slightly larger dovetailed hole, a small curved iron plug being inserted by its side,

which keys it up. This is used chiefly for worked granite.

Fig. 30. A pair of chain lewises, consisting of two curved iron plugs with rings for chain; these are inserted in a dovetailed hole, and when tightened up act similarly to the ordinary lewises.

Fig. 31. A pair of iron dogs, or nippers, with steel-jointed claws, used for lifting rough blocks, and also for fixing.

Fig. 32. Axe, about 12 or 14 lbs. in weight, chisel-pointed, used on granite for removing the inequalities left by the pick and dressing it similarly to tooled work in stone, showing the marks or indents in parallel lines.

Fig. 33. Pick, about 16 lbs. weight, used chiefly on granite, for dressing the inequalities of the rough or rock face down to within 1 in. of the finished face; and also used for scabbling blocks of stone roughly to the required shape.

Fig. 34. Spalling hammer, about 12 to 14 lbs. weight. This has a square edge of about 1½ in., and is a very effectual tool for knocking off rough lumps.

Fig. 35. Patent axe; the body of this is of iron, with a slot at each end, into which a number of parallel thin plates of steel, chisel-sharpened and of equal length, are inserted and tightly bolted together. This is used for granite, and produces the finest description of face, next to polishing.

Fig. 36. A pair of trammel heads, or beam compasses, used chiefly for setting out arcs of circles full size; those made of gun-metal, with steel points, are the best, and a set should be large enough to take a rod 30 ft. long.

Fig. 37. A spirit level for fixing.

Trammel heads & Rod

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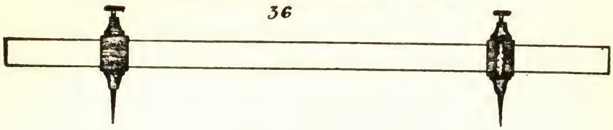
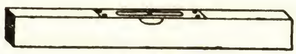


FIG. 37



LEVEL

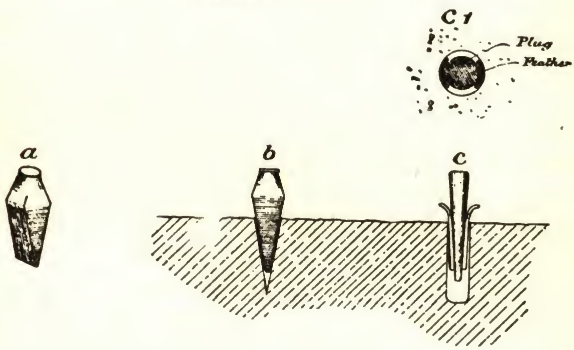
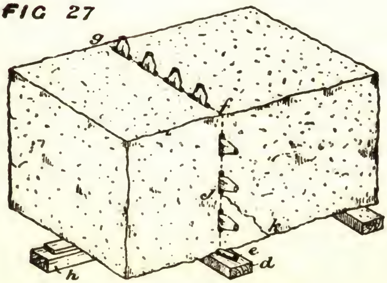


FIG. 38.

FIG 27



COPING OR SPLITTING BLOCK
BY WEDGES

The following appliances are also required for setting out work:

A large platform or drawing board, about 10 or 12 ft. square; or if larger than this, the better. It may be fixed either vertically or horizontally.

A standard five-foot rod.

Two or three straight-edges of various lengths.

Pine rods for story rods, and for setting out lengths of cornices, modillions, dentils, etc.

Pipe-clay and stiff brush, for cleaning off board, rods, etc.

Sheet zinc for moulds, usually No. 9 gauge, this being a good workable thickness. The lines for face, bed, and section moulds have to be carefully transferred to the sheet zinc, and cut to their proper contour or shapes with shears and files.

The foregoing lists do not comprise all the tools and appliances required for every branch of masonry, but only those which are in common use.

All cutting tools are made of the best cast steel, except the pick, axe, and spalling hammer, which are sometimes of iron, steel pointed and faced.

NAMES OF WROUGHT STONE

There are three classes of stones made use of for building purposes; namely, rough stones as they are taken from the quarry, stones squared and dressed in a rough manner, stones dressed and squared accurately.

Stones, rough and left unsquared, are called "rubble." When stones are roughly squared and dressed, they may be "quarry faced"; that is, the face is left just as it came from the quarry; or it may be "pitched faced," or "rock faced," in which case the face will

project beyond the face of the joint; or it may be "drafted," in which the face is surrounded with a chisel draft to allow of the joints being flush on the face.

In cut and dressed stones, there are: 1, the rough pointed; 2, the fine pointed; 3, the crandaled; 4, the tooth axed; 5, bush hammered; 6, rubbed; 7, diamond paneled. There are also other finished stones, that will be discussed in future pages.

The illustrations (Fig. 39) show the different stones when finished. These exhibit the various forms of dressing stone commonly used.

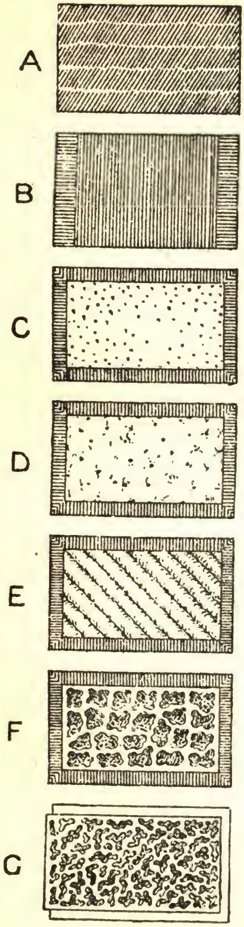


Fig. 39.

A shows a boasted or chiseled face, sometimes termed droved work. The face is finished with a boaster, and the strokes are generally regular and parallel to each other.

In hard-grit stones this face is usually left as finished, and when, as in the case of a building, the whole of the ashlar and plain work is chiseled to the same angle of inclination, the effect is pleasing.

In softer stones a finished face is formed by rubbing the boasted face with sand and water, and removing all chisel marks; it is then called plain ashlar.

B shows ashlar with tooled face.

This is formed with a broad tool, or wide boaster, by a regular succession of strokes, parallel to each other, extending across the whole width of stone, and when finished shows a series of flutes or channels, the size of flutes depending on the texture of the stone.

Considerable skill is required in tooling neatly, and the tooling is somewhat costly, the surface having first to be worked to a boasted face.

C shows ashlar with pick or pecked face, and tooled margin.

This is produced with a point, or in the case of granite with the pick, and can be worked to any degree of fineness.

D shows ashlar with punched rock face, and tooled margin.

This is similar to the last mentioned, but much coarser. In producing it, the punch is driven in almost vertical to the face until the stone bursts out, leaving a series of cavities. When regularly done it looks well, and is very effective, and for large work it gives the appearance of boldness and solidity.

E shows ashlar with broached face, and tooled margin.

This is produced with a point, which forms a furrow with rough ridges, and is worked across the stone to the required angle.

F shows ashlar with rusticated face, and tooled margin.

This is worked with small chisels and points, and sunk down about half an inch, leaving a plain, narrow margin on face; the pattern is irregular, but easily adapted to any space.

G is a rebated or rustic quoin, with vermiculated face.

This is cut out with small chisels, and has the appearance of being worm-eaten.

In order to prepare the stones for dress finishing they must first be brought to a flat surface on one side. This flat surface or face may be "winding," or it may be a plain, flat surface similar to that shown in Figs. 40 and 41.

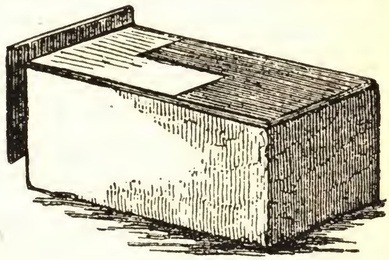


Fig. 40.

When the bed, or one plane surface, has been produced, the required shape of the sides of the block are marked upon the surface with the aid of a square or template. Drafts are then sunk by the chisel across the extremities of an adjacent face with the aid of a square (Fig. 40), or bevel if the sides are not to be at right angles to the bed, and a second face is obtained between such drafts. The process is repeated for the third face, and so on, until the block has been brought to the desired form.

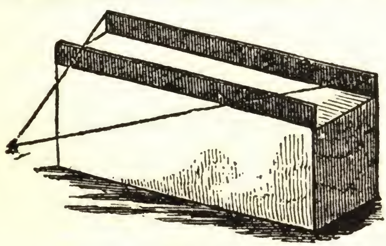


Fig. 41.

Regularly winding surfaces may be obtained in various ways. The simplest plan is when the stone is worked to the proper planes and angles, as just described, to set off the amount of the winding, A*a*, Fig. 42, on the arris and draw the drafts, lines *a*B, *a*C. A series of lines, as *be*, *cf*, *dg*, are then drawn parallel

with A*a*, and another series, *eh*, *fi*, *gk*, parallel to AC. The drafts being sunk at these, so that a straight edge coincides from *b* to *h*, or *c* to *i*, or *d* to *k*, the surface is wrought so that when the rule is applied parallel to the plane A*a* B, it may coincide with the surface at every point. If one end of the stone is less in length than the other, (Fig. 43), the line *a*B must be divided into equal parts, and the lines *be*, *cf*, *dg*, drawn parallel to A*a*. The line CD is then divided into the same number of equal parts in *h*, *i*, *k*; then *ch*, *fi*, *gk* are joined instead of being drawn parallel to AC. The drafts are then sunk until a straight edge agrees from *b* to *h*, and so on, and then the surface is dressed so that the straight edge will coincide in a direction parallel to the plane A*a* B.

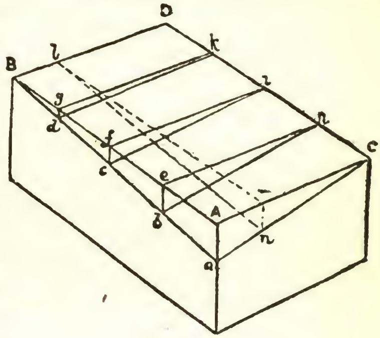


Fig. 42.

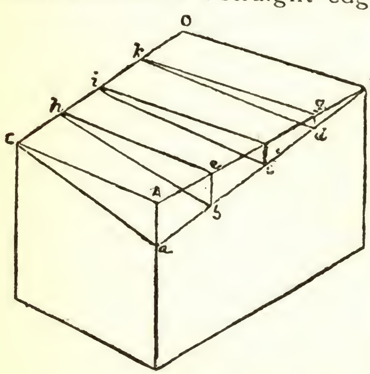


Fig. 43.

Winding surfaces may likewise be formed by the use of two rules, one having parallel and the other divergent edges. These are sunk in drafts across the two ends of the stone until their upper edges are out of winding. The ends of these drafts are then connected by means

of two others formed along the sides of the block, and the entire surface worked down to them until it coincides with a straight-edge placed in a direction parallel to the drafts. The rules used in this process are known as "twisting rules," one of which, as at A, Fig. 44, is, of course, simply a straight edge with parallel to opposite edges. The other, B, is termed a "winding strip," and that portion of it which coincides with the twist of the stone, as shown by the dotted lines, is, of necessity, a triangle.

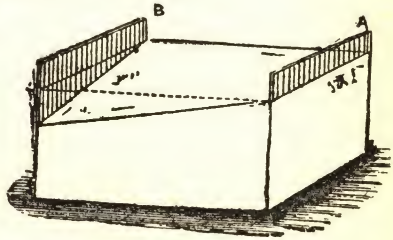


Fig. 44.

The formation of mouldings, columns and the work of the carver and sculptor, as well as that of the marble mason and statuary, form a special branch of the trade, which comprises the production of such parts as enriched cornices, capitals, etc., and is necessarily valued by the time expended upon it; the value of the time varying, in the higher class of carvings, with the artistic reputation of the man employed, and, as this work is not intended to teach the higher artistic phases of the art of masonry, such matter will be left to be dealt with in another volume that may follow this in the near future. The wall mason builds all stone constructions and, from the irregular shapes and sizes of the materials generally at his command for building purposes, is constantly called upon to exercise an amount of judgment and skill far beyond what is required to make a good bricklayer, who mostly lays his regular-shaped bricks according to fixed rules, which he knows

by heart, and ought not to depart from. The rougher the materials, the more skill is required in putting them together; whilst the greater the labor expended in dressing them to regular shapes, the easier is the task the wall mason has to perform.

Large face moulds are sometimes made of several pieces of timber framed together.

When the beds of the courses are to be plane and level they can be set correctly by the level and common straight-edge. When they are to be planes having a given shape a rule must be employed having two straight edges inclined to each other at such an angle that, when one edge is set horizontal by the spirit-level, the other has the proper inclination. If the beds of the courses are to be perpendicular to a straight or curved battering face, their position can be set out and tested by the square.

Curved beds, such as are employed for some special purposes, require the use of suitably curved bed moulds.

In all cases in which economy of time and money has to be studied, the workman should, as far as practicable, avoid curved figures in masonry; for not only are they more tedious and expensive to set out, and to build than straight and plane figures, but it is more difficult to test the accuracy with which they have been executed. A single glance will detect the smallest appreciable inaccuracy in a wall with a straight batter, while the same process in the case of a wall with a curved batter, would require either a long series of measurements, or the application of cumbrous face-mould to various parts of the wall; and this becomes a matter of serious importance in large structures, where errors in form may affect the strength and stability.

All stones, except under peculiar circumstances, should be laid on their *natural* or *quarry beds*, or with their natural beds as far as possible perpendicular to the pressure they have to bear. The strength and durability of the stone depends on this being done—even in cases in which the natural beds cannot be distinguished by an unpracticed eye—for few stones will bear the same pressure applied in the direction of their lines of stratification as at right angles to them; moreover, if the bed of a stone is exposed on the face of a wall, the water will get in between its layers, and frost will soon cause layer after layer to peel off; hence it follows that in projecting undercut mouldings and weathered coping the natural beds should be placed parallel to the side-joints.

The careful bonding of the masonry must be attended to. A wall built of the roughest stones ought to be perfectly stable, though no mortar is used.

The principles of bond, by the stones overlapping and breaking joint throughout the wall, are the same as in brickwork, and should be thoroughly understood by the mason, for upon their skillful application his reputation as a good waller depends.

All dry and porous stones should be well wetted before being laid in mortar, so as to absorb the moisture required for the proper setting of the mortar.

All joints should be filled up solid with mortar.

The thickness of the bed-joints, depending on the smoothness of the beds, must be sufficient to prevent any unequal bearing resulting from actual contact between any irregularities on them.

Where a good appearance is aimed at, all stones exposed to view should be selected free from stains, chiefly caused by oxides of iron.

Iron should never be placed in contact with stonework where, by rusting, it might disfigure it with stains, or split the stone by its increase in bulk during the process of oxidation, or by its expanding and contracting under the influence of heat and cold.

In order to understand the practical operations of building in stone, it is necessary to explain the different descriptions of masonry in ordinary use. These may, as before explained, be included under one of the three following heads, viz.: Rubble, Block-in-course, Ashlar.

If the stone at disposal is thinly bedded, rough or intractable, it should be used as rubble-work; if obtainable in blocks, and more or less easily wrought, it should be used as *block-in-course*, or *ashlar*, according to circumstances.

RUBBLE MASONRY

In *rubble-work* stones of irregular size and shape are laid in a wall, after having been more or less assorted, roughly shaped to fit one against another, and hammer-dressed on their faces with the waller's hammer, according to the quality of the work required.

In the rougher kinds of rubble-work no selecting of the stones takes place, but the waller, having once taken one up, places it in the wall as it will lie best, packing in smaller stones between the larger ones. The stones should be placed on their best beds, and not on their points, which would be liable to crush, in addition to the wedge-like action of such stone, in the interior of a wall, tending to dislodge the facework. No attention whatever is paid to the joints being more horizontal or vertical than naturally results from the bedding and cleavage of the stone used, upon which

the degree of regularity in the appearance of the work mainly depends.

In rubble masonry the rough nature of the work leaves many spaces between the joints, both on the face and interior of the wall; these should be carefully packed up or pinned with spalls, which are the pieces knocked off the rougher stones in order to get them to fit into place.

Care should be taken that the *hearting* or interior of a rubble wall is well packed with spalls and mortar,

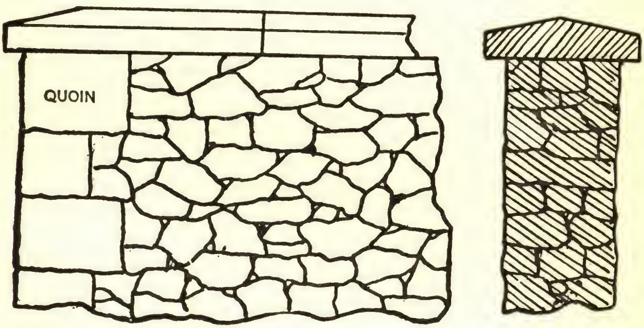


Fig. 45.

and not left full of hollows or mortar alone; to ascertain whether this has been done, take the waller's trowel and plunge it in different places into the heart of the wall.

The spalls must not be placed in the heart of the wall so as to drive like wedges when the weight from above comes on them, or the facing stones will be forced out.

Attention is necessary during the building of rubble, as well as all masonry walls, to insure their being well bonded transversely, and not built up with two thin

scales on each face, tied together by *through* stones, with the core or hearting merely filled in with small pieces. This is a very common fault with masons, who will rely upon the mortar to give stability to a wall which, without it, would fall to pieces under its own weight.

The best stones for rubble masonry are those that scabble freely, and such as lie in 4 or 5-inch beds. Basalts and stones of a crystalline structure are troublesome to use, as they fly under the hammer, but granite and sandstones work in well.

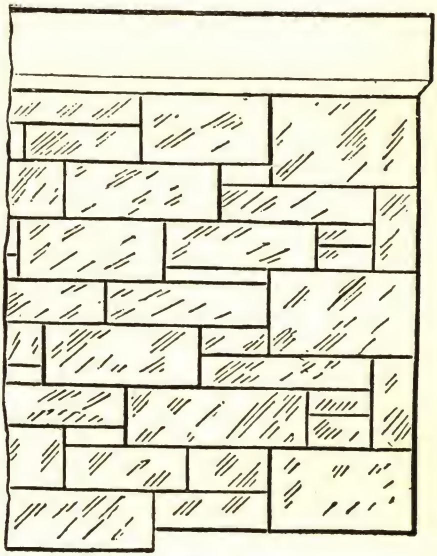


Fig. 46.

Rubble may be either *uncoursed*, *irregular* or *random coursed*, *worked up to courses*, or *coursed*, chiefly depending upon the character of the stone at disposal. Some stones, from their intractable nature, and the absence of any distinct lines of bedding, are especially adapted for uncoursed rubble (Fig. 45), whilst other stones have lines of layers or courses and therefore should be used in square rubble, as shown in Fig. 46.

A portion of a structure in random rubble is shown

in Fig. 47. This shows the quoins or corners in variously finished stones, all of which are named on the illustrations.

Random, common or rough rubble, built up to courses, is indicated in Fig. 48; the courses vary in depth from 12 to 18 inches. The remarks made above apply to this discription.

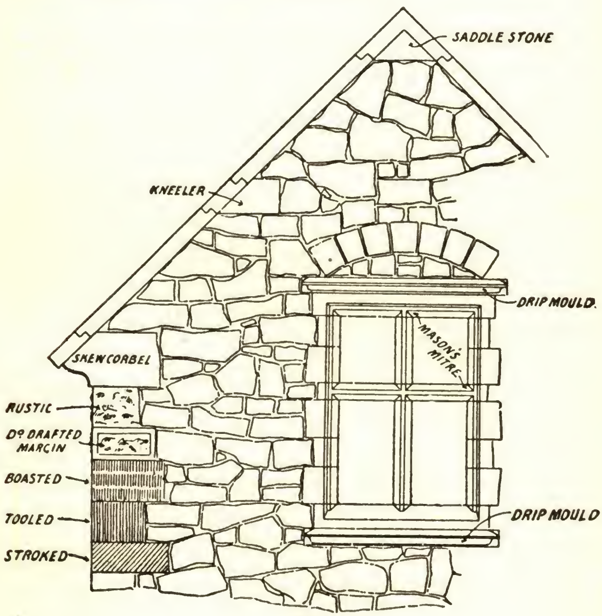


Fig. 47.

Square uncoursed, random coursed, irregular coursed, snecked or squared rubble, are five names implying practically the same description of work. It is shown in Fig. 49, A. There is a certain amount of coursing, but it is not regular or continuous; jumpers are used, but no spalls, and, if careful attention can be

given to bond, the strength of the wall is considerable.

Random with hammer-dressed joints and no spalls on face, or close-pricked polygonal ragwork, often called "cobweb" rubble, is shown in Fig. 49, C. Joints lie in all directions and considerable skill and experience are required to make good work. Freestone is seldom used in this description of walling, as it is chiefly formed with broken boulders, or field stones that have been split apart by dynamite or other explosives.

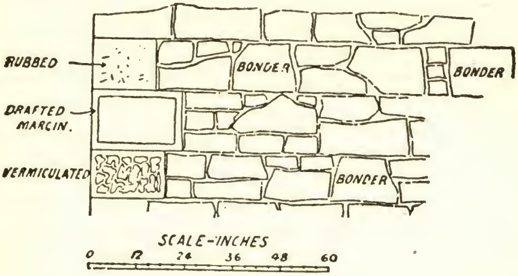


Fig. 48.

Regular coursed rubble (Fig. 49, D)—a very perfect bond can be obtained in this class of work. The courses often vary in depth, but are seldom more than 9 or 10 inches deep. Good stone found in thin beds in the quarry is commonly used.

Joints in any of these examples may be galleted by driving into them, from the face, chips of flint or hard stone.

Technical terms in connection with walling differ so much in different parts of the country that it is often advisable to build a small sample for reference in pricing quantities.

In the rougher descriptions of rubblework, lacing

courses are used to give the wall additional cohesive strength; they are two or more well-bonded courses of masonry or brickwork laid at short vertical intervals.

Block in course, or hammer-dressed ashlar (Figs. 50, A, and 51, A), is intermediate between the best rubble and ashlar. The coursing is regular, and the

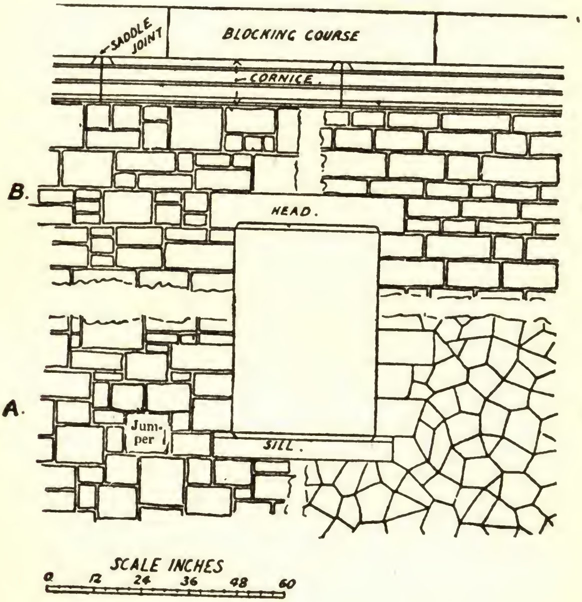


Fig. 49.

blocks are roughly squared; it is frequently constructed of shoddies, which are sound stones less than 12 inches deep. The length of each stone should be from three to five times its depth, and the breadth from one and a half to twice its depth. The exact proportions depend on the degree of resistance which the stone offers to

cross breaking. The same rules as to proportions apply to ashlar work

Ashlar is in large blocks, squared and regular in size, laid in courses varying in depth from about 10 to about 14 inches; the bed joints should be out of winding, but not smooth, and should never be worked slack (hollow on bed) and underpinned with spalls, as in Fig. 55,B; such a practice concentrates the weight on a small area, and leads to crushing or to the joints flushing, that is, the arrises breaking.

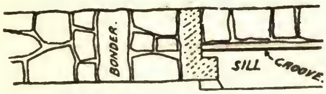


Fig. 50,A.

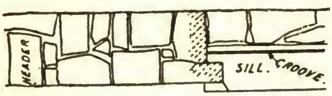


Fig. 51,A.

Joints should be as thin as the class of work allows, but never so as to leave an insufficient cushion of mortar to spread the pressure over the whole joint, as this would lead to flushed joints. Sheet lead has

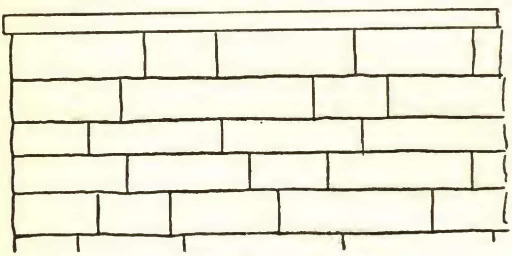


Fig. 51,B.

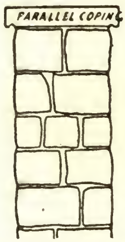
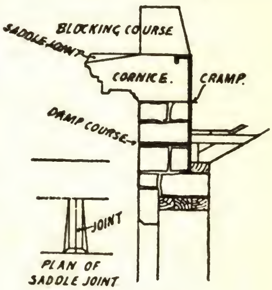


Fig. 52,B.

been inserted in joints subject to great pressure, to equalize it; but it is found that it squeezes outward and flushes the joints, thus more than counterbalancing any good it may do.

When the courses throughout the face of the build-

ing are all of the same depth, the ashlar is regular coursed (Figs. 52 and 53). If they vary in depth, it is irregular coursed; if the courses are not continuous, but broken, it is random ashlar, but the last class of work is unusual. The bond adopted follows the general idea of Flemish, but as all stones are not of the same size, considerable freedom is allowed in bonding, and, except in the best class of work, no attempt is made to keep the perpends. The courses should range with the quoin stones and dressings. Joints can be made less than one-eighth inch thick. Plasterer's putty is frequently used to make the outer part of the joint; it extends inward about two inches. Before being set, each stone



Figs. 52 and 53.

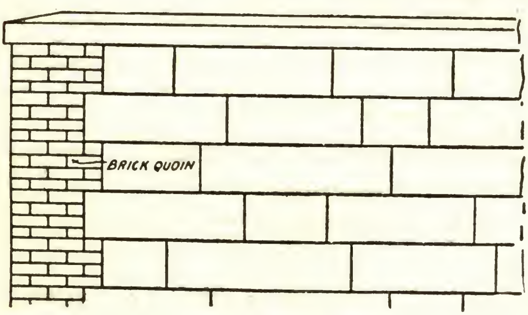


Fig. 52,A.

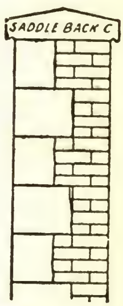


Fig. 53,A.

is laid dry in its place to ascertain that it truly fits. The amount of work on the face of ashlar varies very considerably; a drafted margin round a rough face is the minimum.

Rebated joints and V-joints are shown in Figs. 55,B, 54,B, and 55,B. They are used to emphasize the joints, and at the same time they prevent them from flushing.

Ashlar, so treated, is called rusticated.

A wall built of solid ashlar is necessarily costly, and the term has come almost to imply a facing of ashlar with a backing of rubble or brickwork. The ashlar is often only four inches and seldom more than six inches thick, with bond stones projecting into the backing.

Fig. 55,A.

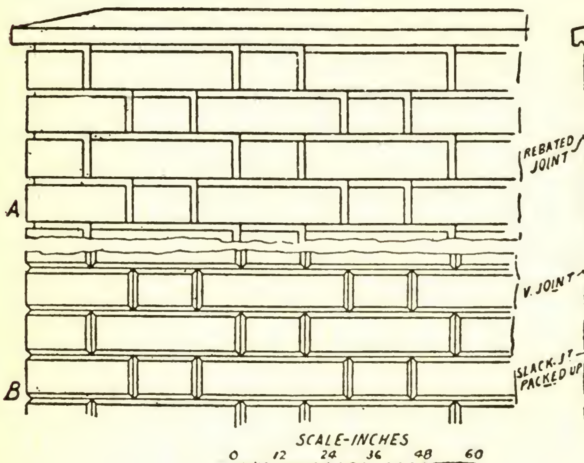


Fig. 55,B.

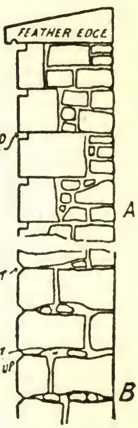


Fig. 54,B.

Figs. 52 and 53,A, show examples of brick ashlar and rubble ashlar. The ashlar should average about 8 inches on the bed, and should bond transversely with the backing. Headers of a length at least two-thirds of the thickness of the wall should be laid, one to every superficial yard of face. The backing, if of rubble, should be built in courses, each leveled up to

coincide with the ashlar courses. If of brick, the ashlar courses must be of suitable depth to allow of the same treatment. The greater number and greater thickness of the joints in the rubble or brickwork lead to more compression in the backing than in the facing, and this tends to cause the wall to bulge outward. This effect can be to a large extent avoided by building in cement or a quick setting mortar. Badly built walls of this description are very liable to collapse in case of fire, owing to the differing behavior under heat of the back and face.

Some may be roughly squared at the quarry; it is then said to be hammer dressed or quarry pitched. Afterward it is sawed to size, half sawing being charged to each of the two blocks produced by one cut. Sawing is now largely done by machinery. Plain work is the labor on a stone to "take it out of winding," or reduce it to a plane surface. Half plain work is similar, but is more roughly done, as for beds and joints. Self faced, natural faced, rock faced, are terms all of the same meaning, and indicate that the face of the stone is left rough as from the quarry, though it may have been scabbled with the hammer to remove irregular projections. A wall built of natural faced stone sometimes is called rustic face (see quoin stone in Fig. 47), but it must not be confounded with the rusticated joints mentioned above.

A stone is taken out of winding by cutting with the chisel a drafted margin along each edge of its face, as shown, and by means of a straight-edge bringing them all into a plane; the intervening space is then worked down to the same plane. If the plane surface be obtained by means of a point instead of a chisel, it is called pointed work; the drafted margin is, how-

ever, first made with the chisel. When the chisel marks are parallel and regular, but not continuous it is called boasted or droved work; when they are parallel, regular, and continuous, it is called tooled work. Stroked work is similar to the last, but the lines make an angle of 45 degrees with the edge. Soft stones are taken out of winding with a comb or drag, which often is merely a piece of a joiner's saw.

Rubbed work is plain work rubbed to a smooth surface; a rub stone is used with sand and water for this purpose. Some stones, such as marble, can afterwards be polished to a glassy surface. Vermiculated work is indicated in Fig. 39. Sunk work is any cutting below the plain surface, as in rebating or weatherings. Circular work is the labor required to form convex surfaces, as the shafts of columns. Circular sunk work is the labor required to form concave surfaces, as in stone channels. Circular circular work is the labor required to form such a surface as a sphere or a basin-shaped hollow. Moulded work is when a moulding of any profile is worked on the edge of a stone, as the cornice in Figs. 49 and 52. Circular moulded work is, in bills of quantities, always kept separate from straight, and is charged at a higher rate. Work is called stopped when the labor, whether sunk or moulded, is not continuous to the end of the stone, as the chamfer on the stone head in Fig. 49.

Quoins may be built of larger or differently worked stones from the remainder of the wall. A brick quoin may be built to a rubble wall, and more rarely to ashlar work, as in Fig. 51. In some varieties of rubble it is almost impossible to construct a sound quoin unless material superior to the bulk of the wall be used.

Ashlar work is constantly used for the dressings to

windows and doors in brick and rubble walls; Fig. 47 is an example. Reveals with recesses may be formed as in Figs. 50 and 51.

Stone window-sills for sashes and casements should be set to project about 2 inches from the wall face; they are weathered and throated, so that rain-water may run off the surface and drop clear of the wall beneath. They may be moulded on the front, and stools are worked on the ends for the brick or stone jambs to rest on.

To prevent water from being blown in between the stone sill and the wood sill resting on it, a water-tongue, usually of galvanized iron, 1⅛ in. by ¼ in., is set in a groove in the stone and wood; it and the wood sill should be bedded on the stone with white lead ground in oil. If sills are set flush with the wall, a separate drip mould (Fig. 47) should be fixed immediately below to serve the purpose of a throating.

Window-heads are made as wide on the bed as the reveal; the head of frame is behind them, with lintel (with or without relieving arch) over. A separate drip mould over the head, as in Fig. 47, protects it from water stains from above.

Coping stones are made in many forms, and are often handsomely moulded. As their purpose is to keep wet out of the wall, they should be chosen as nearly impervious to moisture as may be, cut in long lengths, say 5 feet or so, to reduce the number of joints, weathered and throated, and set and jointed in cement. These are respectively parallel saddle-back, and feather-edge coping; the first should only be used in inclined situations, as on gable walls. Raking copings are prevented from sliding by dowels built into the bed on which they rest. The same object is

served by kneelers, which are coping stones provided with horizontal tails (Fig. 47). There may be several of these in a large gable. Those at the foot are sometimes in the form of corbels (Fig. 47), when they are called skew corbels. The large triangular stone at the head of a gable (Fig. 47) is variously called summer stone, saddle stone, or ridge stone.

A cornice at the head of a wall (Figs. 49 and 52) may be one or more stones in height, moulded in front, and weathered and throated. There should always be sufficient tail weight for the stone to rest in its place without the assistance of the cement mortar in which it is bedded and jointed. Vertical cramps, say 2 in. by ½ in., 4 or 5 feet long, and one to each length of stone, or a blocking course, may be added to increase the stability.

In addition to mortar or cement, special connections, such as cramps, dowels and joggles, may be adopted for binding stones together; these terms are used rather loosely and sometimes interchangeably. A cramp is a connecting piece of metal, slate, or hard stone, so shaped that it holds two stones together. A dowel is a short, thick pin or narrow plate of metal, slate or stone, fitting into two sockets; it is sometimes called a plug, especially when fixed in the bed joint, or when it is formed by running molten lead into a dowel hole. Joggle is a comprehensive term, and includes all cases where a projection on one stone fits a corresponding sinking in the next.

Regular coursed rubble, as shown in Fig. 56, is applicable where the beds, though thin, are pretty regular, so that a sufficient number of stones of a uniform depth can be got to allow of their being laid in regular courses of one stone only in depth.

Dry rubble walling is the simplest class of rubble work, and consists of stones roughly hammered, and bedded by pinning spalls, without any mortar. It requires considerable skill to lay a wall up of this kind and keep it up straight and fair on both exteriors.

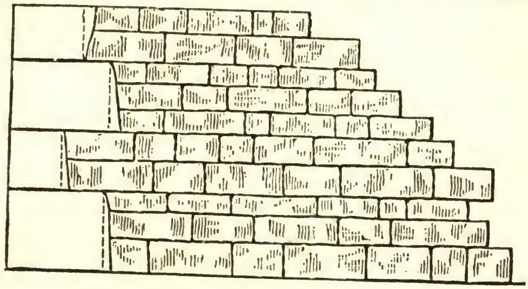


Fig. 56.

This kind of a wall should be wider at the base than at the top or coping. They are generally built to lines strained through trestles or horses, as shown in Fig. 57. This saves much time, as it avoids the necessity of plumbing the faces.

Dry rubble walling is generally built in courses about

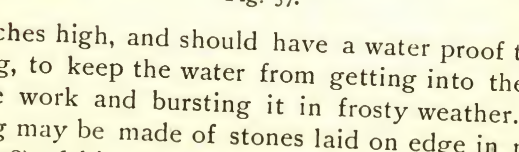


Fig. 57.

12 inches high, and should have a water proof top, or coping, to keep the water from getting into the body of the work and bursting it in frosty weather. The coping may be made of stones laid on edge in mortar (Fig. 58) of bituminous concrete, or, for want of anything better, clay puddle, or even sods.

Rubble ashlar consists of an ashlar stone face with rubble backing (Fig. 59), and is subject, even to a still greater extent than brick ashlar, to the evils caused by unequal settlement.

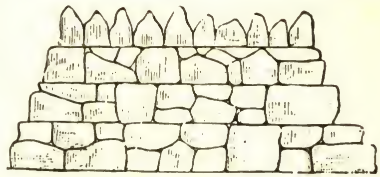


Fig. 58.

To avoid these evils, the stones and joints of the rubble backing should, as before mentioned, be made as nearly as possible of the same thickness as those in the ashlar facing, or, if the joints are necessarily thicker, there should be fewer of them, so that the total quantity of mortar in the backing and face may be about the same. This can seldom be economically arranged in practice, but it should be remembered that the more numerous and coarser the rubble joints, the worse the construction becomes.

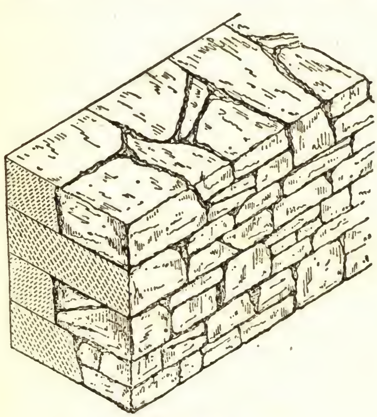


Fig. 59.

The ashlar should be bonded in with through stones or "headers," as previously described; their vertical joints should be carefully dressed for some distance in from the face, and their beds should be level throughout; the back joint and sides of the tails of the stones may, however, be left

rough; the latter may even taper in plan with advantage, and they should extend into the wall for unequal distances, so as to make a good bond with the rubble, the headers from which should reach well in between the bond stones of the ashlar. Through stones may be omitted altogether, headers being inserted at intervals on each side, extending about two-thirds across the thickness of the wall.

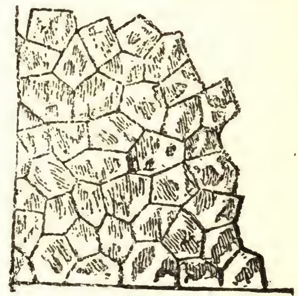


Fig. 60.

Care must be taken that the stones in the ashlar facing have a depth of bed at least equal to the height of the stone. In common work the facing often consists merely of slabs of stone having not more than from 4 to 6 inches bed, with a thin scale of rubble on the opposite side, the interval being filled in with small rubbish, or by a large quantity of mortar, which has been known to bulge the wall by its hydrostatic pressure.

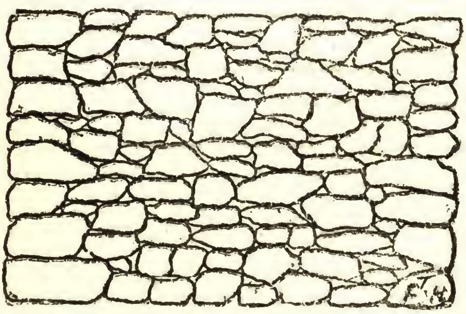


Fig. 61.

The ashlar facing is in all respects, except those above mentioned, built as described in the section on ashlar, and the backing may be of random rubble done in courses from 10 to 14 inches high,

according to the depth of the stones in the facing.

The illustration, Fig. 59, shows the section of a wall 3 feet thick, with an ashlar facing composed of good substantial stone.

Irregular rubble, as before stated, is built up with split boulders, and when finished has an appearance as shown at Fig. 60. When a good face is formed and nice joints made, this kind of walling presents a very fine appearance.

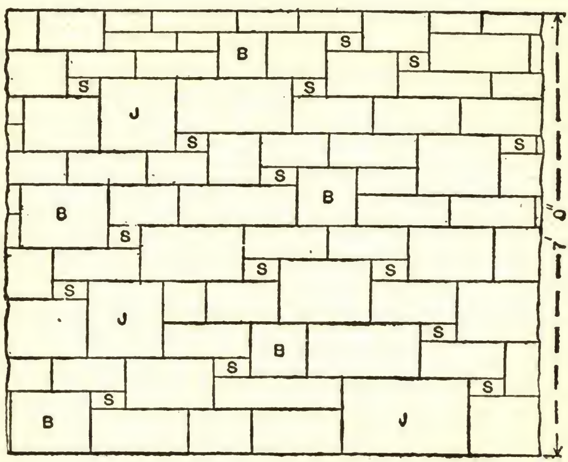


Fig. 62.

Coarse rubble without dressed quoins has an appearance similar to that shown in Fig. 61.

Snecked rubble is a method of building in which almost any size of dressed stones may be used. The stones marked Fig. 62, are jumpers, B are bonders, and S are snecks. Jumpers must not be used too freely in a wall of this description, or the wall will collapse, especially if any great weight is placed on the top of

the wall. Bonders should be evenly distributed throughout the whole wall in order to strengthen it, the name bonder showing that the stone goes through the wall to the inner face. Snecks, which determine the name of the wall, should be built in as often as possible. In a block joint two stones are butted against two stones, or two stones are butted against three stones (Fig. 63); or the stones are butted against each other without any attempt at bonding or breaking the joints.

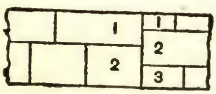


Fig. 63.

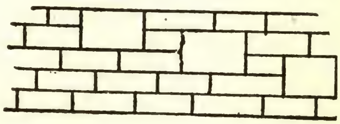


Fig. 64.

In Fig. 64 a common arrangement with single snecks beside each jumper is shown. In engineering works on a large scale, this is frequently done where a masonry wall has to resist forces likely to overturn, or having a tendency to overturn, the whole mass, or a part of it. It is claimed that the snecked work is stronger than coursed work, inasmuch as each jumper forms a vertical tie between two courses, and tends to prevent a too long horizontal course from yielding as a hinge.

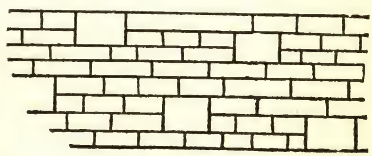


Fig. 65.

Some engineers seem to consider that single snecks place the jumpers too near to one another, and thus probably form a diagonal line of rupture. An arrangement like Fig. 65 may thus be preferred by some, giv-

ing a short course instead of a single sneck between each pair of jumpers.

Several of the vertical joints in Fig. 65, are badly arranged, tending to become perpends. Joints nearly vertical over one another should be separated either by a jumper or, if at all possible, by two ordinary courses.

A fault of some of the work executed is that it seems more like brickwork than masonry. There ought never to be the rigid regularity of brick bond in the face of a masonry wall. The regular irregularity—if we may so term it—of a well-built wall shows the skill of the craftsman, and is even appreciated by those able to judge as the correct placing and true economy of every cubic inch of material which the workman has had at his disposal.

Bond.—The best bond in masonry is that which shows on the face of the work alternate headers and stretchers in each course, as in Flemish bond in brick-work, each header coming over the center of a stretcher in the course below. In such work one-third of the face consists of headers, if the length of the stretchers is twice the breadth of the headers; but as stones are rarely cut to exactly the same dimensions, it may be laid down that not less than one-fourth of the face of the wall should consist of headers and that the stones should break joint from once to one and a half times the depth of the course.

Joints.—The thickness of the joint will vary from one-half to one-eighth of an inch, according to the smoothness of, or amount of work bestowed upon, the beds, as it must be sufficient to transmit the pressures from stone to stone, without permitting of actual contact at any point of their surfaces. The mason's joint,

or a properly struck joint, is the best which can be used.

Flush Joints.—Care should be taken to prevent the use of *flush* joints, which are formed by hollowing the beds below the plane of the chisel draughts run round the edges. This was sometimes done by the Greeks, in order to get perfectly close joints; but, by throwing all the pressure on the edges of the stones, they frequently splinter off and spoil the look of the work.

As flush joints cannot be detected after the stones are laid, the masons must be well looked after while at work upon them.

With a view of guarding against the splintering, or *spalling*, of the arrises of cut stonework, as in columns carrying heavy weights, seven or eight pounds sheet-lead is frequently placed between the stones. The lead, which is not allowed to reach within less than one inch of the edges of the stones, is thought to equalize the pressure over the beds by yielding to any slight irregularities on them, but the use of lead instead of mortar is a great mistake. It has been found that stones bedded on thin pieces of pine, instead of lead, equal in area to the bed-joint, bore a greater crushing force than stones double their sectional area bedded on lead in the usual way. The lead which had been used showed no signs of accommodating itself to the irregularities of the beds.

The joints of stone columns are often raked out about one inch deep, and pointed up when there is no longer any fear of their settling. The arrises of stones are also prevented from spalling by cutting them back, though this is generally done merely to give a bolder effect to certain parts, such as the quoins and lower stones of buildings.

Open Joints.—Open joints, resulting from projections beyond the plane of the chisel draughts, must also be avoided, especially in the beds, as tending to distribute the pressure unequally over them.

Rusticated Joints.—Rustic work properly applies to facework left rough from the hammer, though it also applies to a debased class of masonry, picked into deep holes, or honeycombed all over, to give a rough effect; but the term rustication, or rusticated, is also much used to denote masonry in which the joints are either chamfered, or sunk square below the facework.

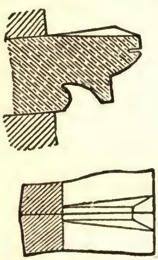


Fig. 66.

Saddle or Water-Joints.—In addition to the sloping off or weathering of the upper surfaces of stonework exposed to the rain, as in copings, cornices, and string courses, it is well to *saddle* the joints, by leaving them rather higher than the rest of the work, as in Fig. 66, in order to throw the rain away from the joints, and so prevent any water finding its way through them, and down the face of the work. Such joints are called *water-joints*.

Rebating.—The adhesion of mortar or cement, and the weight of the stones themselves, cannot always be relied upon as affording sufficient stability to stonework, especially when not built into the body of the work, where they would be held in place by the superincumbent weight; hence different methods are resorted to in order to give additional stability, such as *rebates*, *joggles*, *cramps*, *lead plugs*, etc.

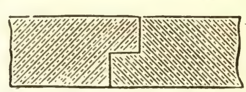


Fig. 67.

A rebated or lap joint (Fig. 67) is formed by cutting away a portion of the edge of each stone, so as to

allow them to lap over each other. Fig. 68 shows the proper way of making a rebated joint on a slope, as in the case of a barge course or coping on the gable end of a building; water is thus effectually kept out, which would not be the case if the side *a* were uppermost.

Joggling.—Stones are said to be joggled together when prevented from sliding by a projection or *he-joggle*, on one stone, fitting into a corresponding notch, or *she-joggle*, in the other stone (Fig. 69).

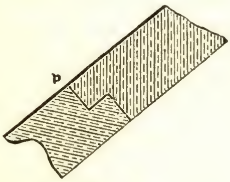


Fig. 68.

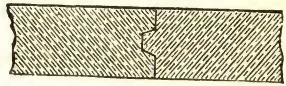


Fig. 69.

The he-joggle is generally cut square, and should taper slightly from the shoulder to the end, being stronger and easier to cut and fit into place when so made. If, instead of one or more square joggles, the joggling is continued along the joint, it becomes a *tongued and grooved joint*.

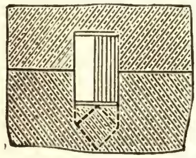


Fig. 70.

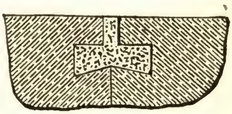


Fig. 71.

Doweling.—The above methods, except in special cases, as in Fig. 68, are wasteful both of labor and material; a better plan, therefore, is to sink, exactly opposite each other, two *she-joggles* or *dowel holes*, one in each stone, either circular or square in section, and fit into them a *dowel* or pin (Fig. 70), either of some

hard stone, such as greenstone, granite or slate, or of brass, zinc, or copper.

Copper dowels are the best, but very expensive; iron are the strongest, but should not be used unless perfectly secured from air and moisture, for fear of their cracking the stone during the process of oxidizing, and as an additional precaution they should be thoroughly tinned or galvanized.

There is nothing, perhaps, better, on the whole, than good hard slate dowels run with brimstone or cement.

Where very perfect workmanship is required, as well as when placed so as not to admit of being run in, the pins are made to fit the dowel holes accurately, being slightly tapered towards the ends, to secure a good fit and facilitate the setting of the stones.

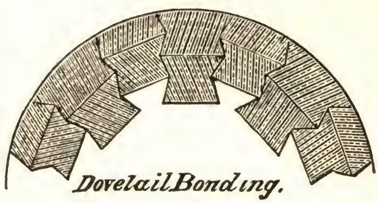


Fig. 72.

Lead Plugs.—In connecting stones by means of lead, plug holes, which may be dovetailed if thought necessary, are made, one in each stone, exactly opposite each other, as in Fig. 71, with a channel leading to them from the top of the joint, through which molten lead is run into them. The bottom of the plug holes should slope downwards, so as to carry the lead into them at once, as well as to give the stone a more secure hold of the lead. Great care should be taken in running in lead that there is no moisture in the holes, whicn, if suddenly converted into steam, might cause a serious accident.

Dovetail Bonding.—In masonry constructions intended to resist the shocks of waves, in addition to the methods given above, the stones may be held in posi-

tion by being dovetailed one into the other (Fig. 72), as was done by Smeaton at the Eddystone lighthouse; but good cement and dowels would no doubt be equally efficacious, and at the same time less expensive.

Tabling.—Stones of different courses may also be given great resistance to lateral shocks by *tabling* (Fig. 73), in which a flat projection cut on the bed of one stone fits into a corresponding sinking in the bed of the one under or overlying it. This method, however, is wasteful both of material and labor.

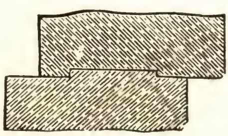


Fig. 73.

Fig. 74.

Securing Bolts, etc., in Stonework.—Iron bars and bolts are generally secured in stonework by being enlarged or jagged at the ends—bolts so made are called *rag-bolts*—let into dovetailed holes in the stone, and run with lead (Fig. 74). Brimstone is often preferred to lead, being cheaper and less liable to loosen by expansion and contraction.

Protecting Cut Stonework.—Any projecting or carved stonework in a building should be boxed up with rough boarding, after it has been set, to guard against its being injured by the carelessness of workmen, or by bricks, etc., falling from the scaffolding, during the progress of the work. The treads and nosings of steps should also be boarded over for the same reason, as well as to protect them from the rough traffic.

All the cut stonework should be well pointed and cleaned down before the building is given over for use.

ARCHES AND JOINTS

In the first part of this work, designs for many kinds of arches were given and described, and the rules given are in many cases applicable for stonework; so I will not burden this part with many examples, as those already exhibited, along with the few presented herewith, will be ample to serve the purposes of most workmen, and before proceeding further, it may not be out of place to explain a few of the terms that are made use of in connection with the construction of arches:

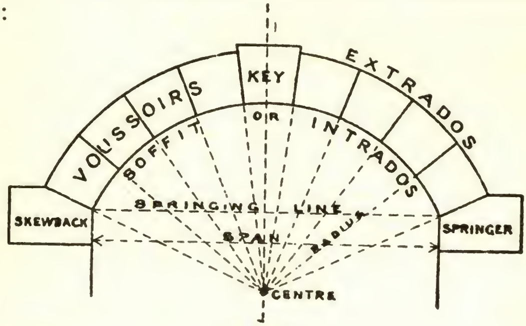


Fig. 75.

The face of the arch is the *front*, or that portion shown in elevation.

The *under surface* or *soffit* is called the *intrados*, and the outer surface the *extrados*.

The *voussoirs* are the separate arch blocks composing the arch, the central one being the *keystone*.

The *springers* are the first or bottom stones in the arch on either side, and commence with the curve of the arch.

The *skewbacks* generally apply to segmental arches, and are the stones from which an arch springs, and upon which the first arch stones are laid.

The *span* of the arch is the extreme width between the piers or opening; and the *springing line* is that which connects the two points where the intrados meets the imposts on either side.

The *radius* is the distance between the center and the curve of the arch.

The highest point in the intrados is called the *crown*, and the height of this point above the springing is termed the rise of the arch.

The *center* is a point or points from which the arch

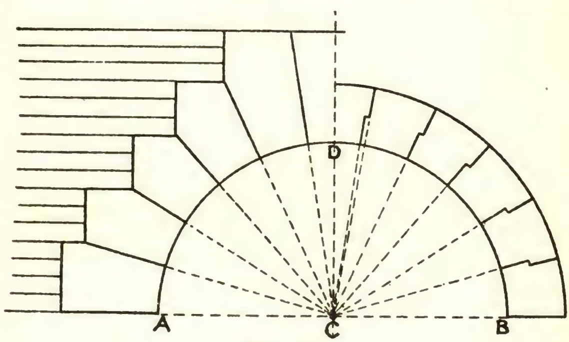


Fig. 76.

is struck; and lines drawn from this center or centers to the arch are radiating joints, and are also called *normals*.

All joints in arches should be radii of the circle, circles, or elipses forming the curve of the arch, and will therefore converge to the center or centers from which these are struck.

Fig. 75 shows a segmental arch, in which the abovementioned terms are illustrated.

Fig. 76 is a semicircular arch, *AB* being the span and *CD* the rise; the left-hand half has the ordinary joints radiating from the center *C*, and the right-hand half,

with rebated or step joints, also radiating from the center *C*. This last is a sound and effective joint where great strength is required, and there is also no tendency to sliding of the voussoirs.

Fig. 77 shows a semi-oval arch approaching in form that of the ellipse, and struck with three centers. This form of arch has a somewhat crippled appearance at the junction of the small and large curves, and is on that account not pleasing to the eye

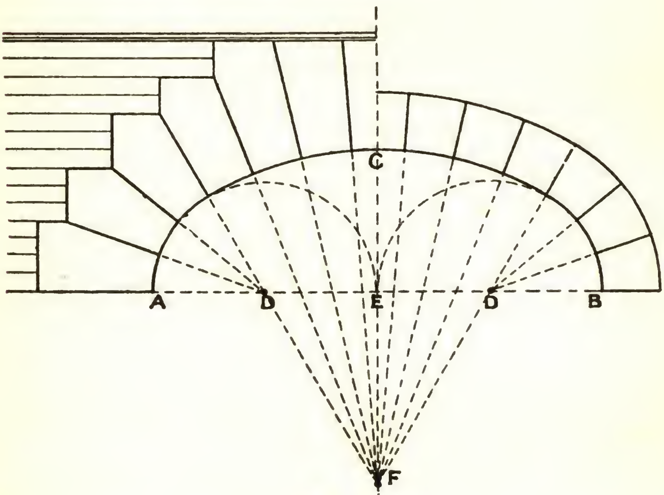


Fig. 77.

It may be here observed that the true ellipse is obtained from an oblique section of the cone, and no portion of its curve is any part of a circle, and cannot, therefore, be drawn by the compasses or from centers.

The method of setting out and drawing the joints requires but little explanation, *AB* being the span, *CE* the rise, and *DD* and *F* the centers, from which

the curve is struck, the joints converging to their respective centers.

The left-hand half is shown with square bonding on face, and the right-hand half shows line of extrados.

Fig. 78 is a Tudor arch, based on the curve of the hyperbola.

Let *AB* be the span and *CD* the rise of arch; erect perpendicular at *A*, and make it equal in height to two-fifths of the rise, as at *AC* and *CD*, each into six equal parts, and draw lines from 1 to 1, 2 to 2, 3 to 3, etc., and the line drawn through the intersections of

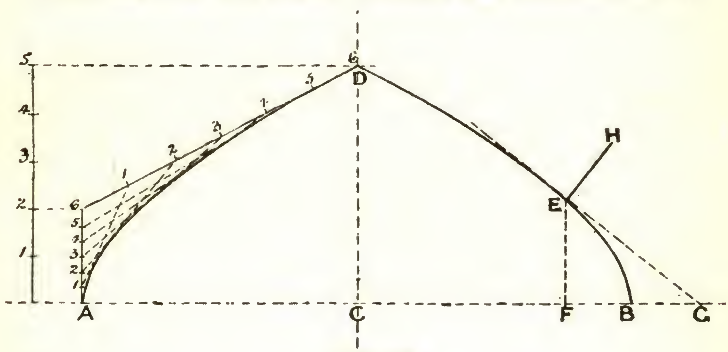


Fig. 78.

these points gives the curve of one side of the arch. The other side is obtained similarly.

A thin, flexible lath is generally used for guidance in drawing an easy curve through the points of intersection.

To draw the arch joints:

At any point in the curve, say at *E*, drop a perpendicular on to the springing line, as *F*, make *BG* equal *BF*, and from *G* draw line to *E*, which is tangent to the curve, and erect the perpendicular *EH*, giving the arch joint required.

The other joints are described in the same manner.

Fig. 79 is another example of the Tudor arch and is a parabolic curve.

Let *AB* be the span and *CD* the rise, erect a perpendicular at *A* and make it equal in height to half the rise, and proceed as in previous figure.

To draw the arch joints:

At any point in the curve, say at *E*, draw the chord line *BD*, and bisect it in *F*. Join *FG*, cutting the curve in *H*, and from the point *E* draw line *EJ* parallel to *EF*, cutting *FG* in *J*; on the line *FG* make *HK*

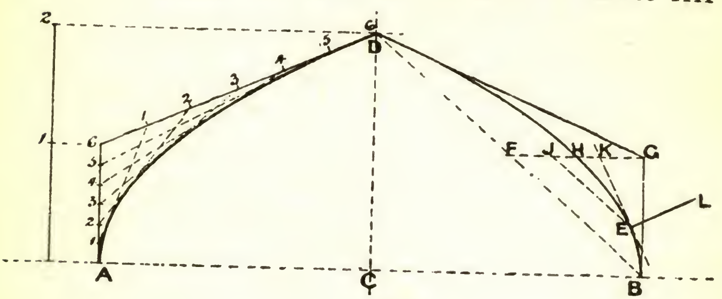


Fig. 79.

equal to *HJ*, join *EK* and draw *EL* perpendicular to *KE*, thus giving the joint line required.

The other joints are described in a similar manner.

Fig. 80 shows a straight or flat arch, the joints radiating to a common center.

On the right-hand half the joints are not continued through to soffit or top, but have a small portion squared on, thus relieving the acute angles of arch blocks, which are otherwise liable to fracture.

The springer on left hand has additional strength in having a square seating on skewback.

In flat arches a camber of an eighth of an inch in a

foot to soffit is usually given to allow for any depression or settlement.

Fig. 81 is another example of the flat arch; the left-hand half has rebated or step joints, and the right-hand half has joggle joints. All these joints converge to a common center.

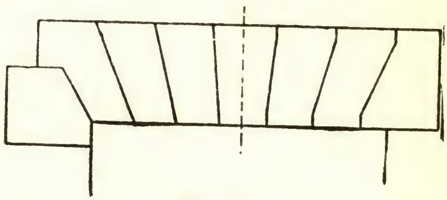


Fig. 80.

Fig. 82. — In this figure a lintel with double joggle vertical joint is given.

Fig. 83 shows a lintel with curved joggle joints, and is an example not often met with.

The form of joint in Figs. 81, 82 and 83 is a little wasteful of material; but where stone is plentiful and in small blocks, good lintels may be obtained. Many examples of these may be seen in our modern Gothic buildings.

Fig. 84 illustrates a window or door head with quadrant corners; the stretching-piece or key is in one stone, with arch-joints resting on the skewbacks.

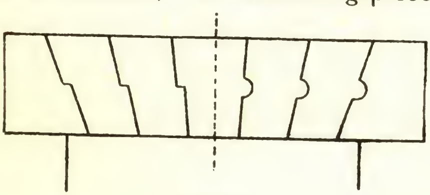


Fig. 81.

Fig. 85 is another form of head, the square seating in each stone giving additional strength, and the joints converge to common centers.

Fig. 86 shows three joints used in landings.

A is a joggle joint, commonly called he and she-

joggle. A tongue is cut slightly tapering on one edge, fitting into a corresponding groove worked in the other edge. Run in with cement, it forms a strong and secure joint.

B is a rebated joint; this is sometimes undercut.

C is a bird's-mouth joint. Grooves are roughly cut in on the edges of these joints opposite each other, and the cavities run with cement grout. Slate dowels are also laid longitudinally in the joint and run with cement.

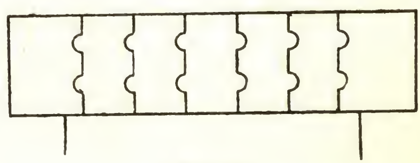


Fig. 82.

Fig 87 is a horizontal lintel or architrave spanning an opening, with an apparent vertical joint, but concealing a secret arch joint. This is used chiefly in colonnades, porticoes, etc., where stones of a sufficient length are not attainable, and sometimes also for convenience of hoisting and fixing.

An indent is formed the shape of the reverse of a wedge in joint of abutment, and a wedge-shaped projection is cut in keystone, fitting neatly into the indent.

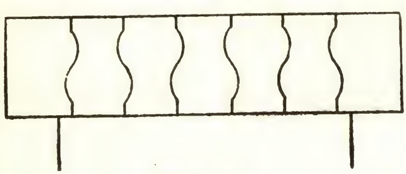


Fig. 83.

This makes a good and secure joint without doweling or cramping.

Fig. 88 shows sketch of weather or saddle joint in cornice. This joint is made by leaving at each end of the stone a ridge or roll, the formation of which is generally left till after fixing. This roll effectually prevents the water running through the joint. The

roll is not usually seen from the front, as the nose of cornice is continued straight through the joint, although it is also in some cases made a feature of.

This joint is used chiefly for cornices and window sills where there is a large projection.

Fig. 89 exhibits a rebated joint in gable coping.

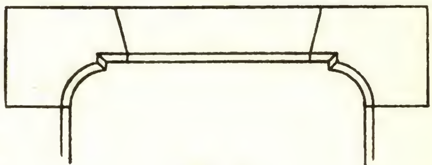


Fig. 84.

This joint is serviceable, inasmuch as it keeps the water out of the joint and the wall dry, although it is somewhat expensive.

Fig. 90 is an example of various bed joints in stone spires, being respectively:

A. A horizontal bed joint.

B. A bed joint at right angles to batter

C. A rebated or stepped bed joint.

D. A joggle or tabled joint.

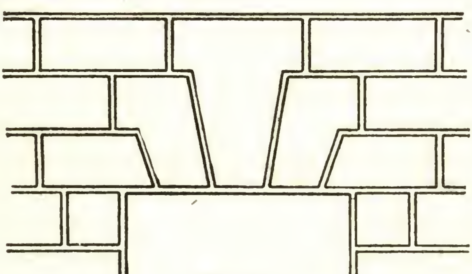


Fig. 85.

The bed joints of the stones are usually cut at right angles to the batter or face of the spire, as at B; but horizontal beds, as at A, are supposed not to involve so much thrust at the base. But for obviating any

outward tendency, a chain or rod-bond, united at the angles and inserted in a cavity at the base of the spire, is sometimes used.

The two bed joints C and D are both a little wasteful of material, but for stability and strength these are by far the best form of joints.

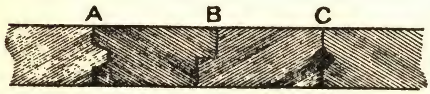


Fig. 86.

A word may be said as to the thickness of the work; this will depend chiefly on the height of the spire and the quality of the stone. From ten or twelve inches at

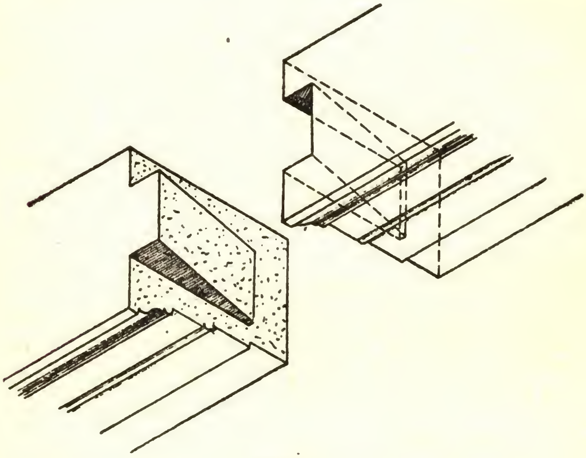


Fig. 87.

the base, diminishing to six inches or even less at the top, may be generally considered sufficient.

The stonework of the spire of Salisbury Cathedral (the spire, reckoning from the tower, being 204 feet in height) is two feet thick at the base, and gradually

diminishes in thickness to about twenty feet above the tower, where it is reduced to nine inches, and is continued at that thickness to the capstone at the summit.

Fig. 91 shows ashlar in courses with joggle joints. This is a very unusual form of joint, and is used, no doubt, more for effect than utility. There is a waste of material and labor, and a better result may be obtained by the use of slate cramps. However, there are some examples of it in modern buildings.

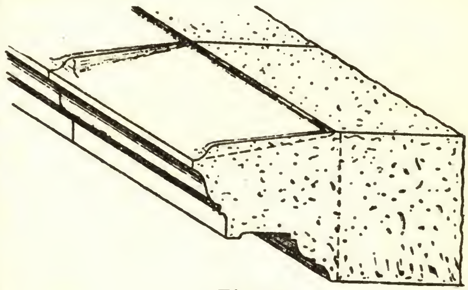


Fig. 88.

Fig. 92 is a seating to sill, with a slate or copper dowel to prevent lateral motion. Mortises are cut opposite to each other in the two beds, and the dowel made secure by being run in with cement.

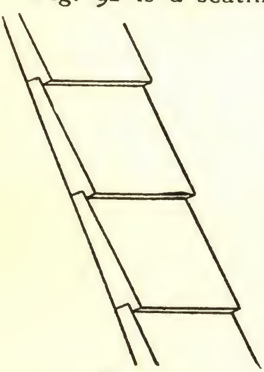


Fig. 89.

The dowel is a most useful adjunct in good and secure fixing.

Fig. 93, A, is a metal cramp for securing joints together. A chase or groove is cut in the stone of a sufficient width and depth, and at each end a mortise hole is cut to the exact size of inside of cramp, so that it fits tightly and requires to be tapped into its place; it is then run with melted brimstone or cement.

The use of iron cramps and dowels in connection with stone is generally attended with some danger, on account of the iron rusting, which causes an increase in size, and subsequent fractures and discoloration of the stone. But if the iron is properly protected by galvanizing or japanning, the risk is reduced to a minimum.

The best metals for cramps, dowels, etc., are copper, gun metal, or brass, but these are expensive and are therefore not much used.

B is an example of a slate cramp also used for connecting joints together, and is an excellent and economical substitute for metal. It is made dovetail in shape, let in flush to the bed of the stone, and then run in with cement.

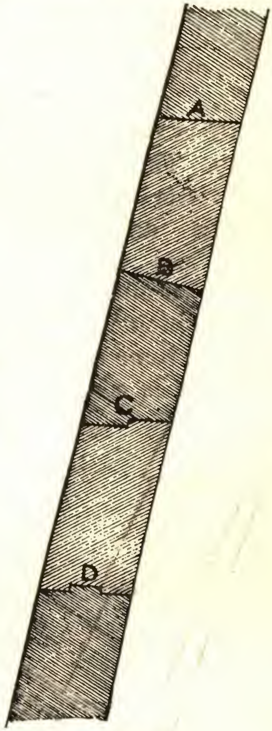


Fig. 90.

Fig. 94 shows a plugged or lead doweled joint. This is chiefly used in copings, curbs, strings, arches, etc., and prevents the joint working loose or "drawing."

Two holes, dovetail in shape, are sunk in the joints opposite each other and a small groove is cut from the top to each hole and run in with cement.

Slate dowels are sometimes used for this purpose, and run in with cement.

Fig. 95 shows a lewis, or holding-down bolt, let in a dovetail hole and run in with lead.

The openings in stone of small span arches are generally bridged by stone lintels in one piece, or lintels built on an arched construction if a number of

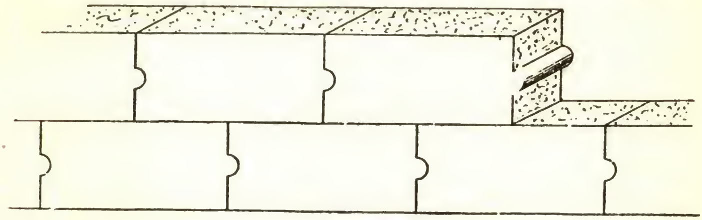


Fig. 91.

stones are used. If lintels of one piece are employed in walls other than ashlar, a rough arch is generally built above to relieve the lintel of the weight of the superincumbent wall, as shown in Figs. 96 to 98. A

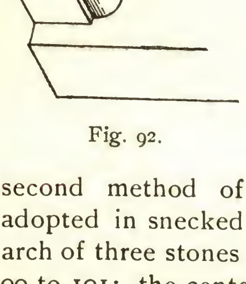


Fig. 92.

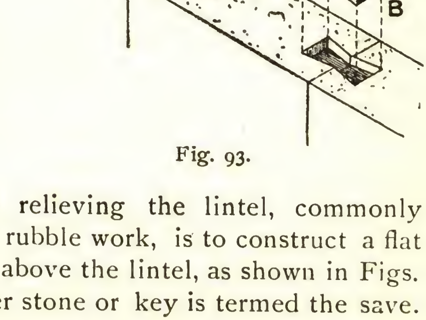


Fig. 93.

second method of relieving the lintel, commonly adopted in snecked rubble work, is to construct a flat arch of three stones above the lintel, as shown in Figs. 99 to 101; the center stone or key is termed the save. In bedding the save stones no mortar is placed on the

lintel, but the stones are supported in their position by means of small wood wedges. After a sufficient mass of the wall has been built to tail down the side saves, the wedges are removed. In finishing the wall, the joint between the saves and the lintel is pointed only; thus no weight from the wall above is brought to bear on the lintel.

A large number of stone openings are formed with flat heads, and where stones of sufficient dimensions cannot conveniently be obtained in one piece, some form of flat arch is adopted.

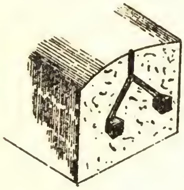


Fig. 94.

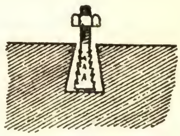


Fig. 95.

Figs. 102 to 105 show a flat arch, with secret joggles. These latter are worked out of the solid stone, the key having two joggles; the springer is recessed only, and is made sufficiently long to tail well into the wall, the remaining voussoirs being joggled on one bed-joint and recessed on the other; the cornice over window in this example is supported by a console or bracket.

Figs. 106 to 108 show the construction as a flat arch, the bed-joints stepped to prevent any voussoir sliding on its bed-joint. This method is largely used for terra-cotta work. This example illustrates an architrave about window, supported at sides by a half column with cushion frieze and segmental pediment above. The internal jambs are splayed, and illustrate

Fig. 96.

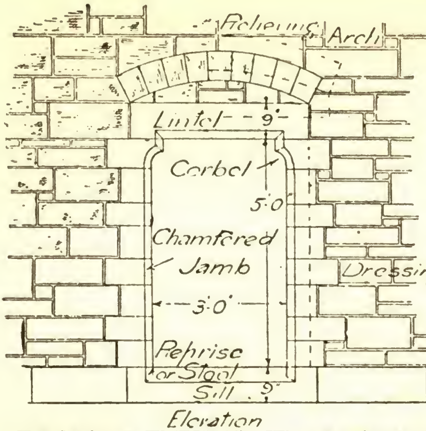


Fig. 98.

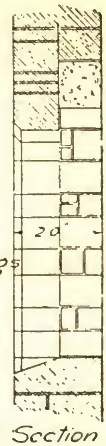


Fig. 97.

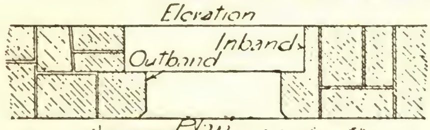


Fig. 99.

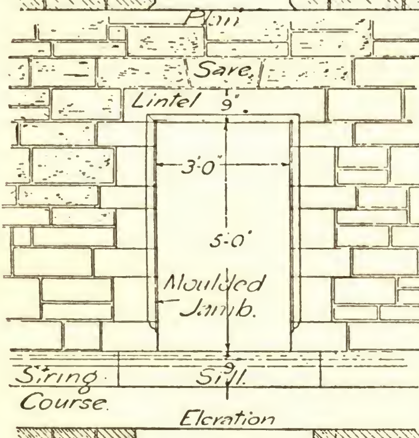


Fig. 100

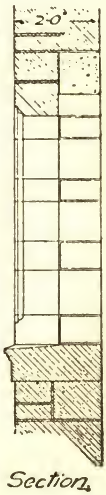
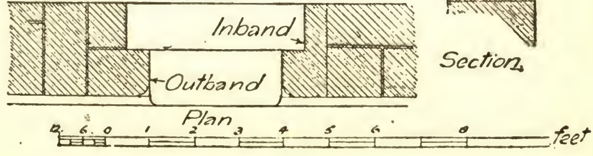


Fig. 101.



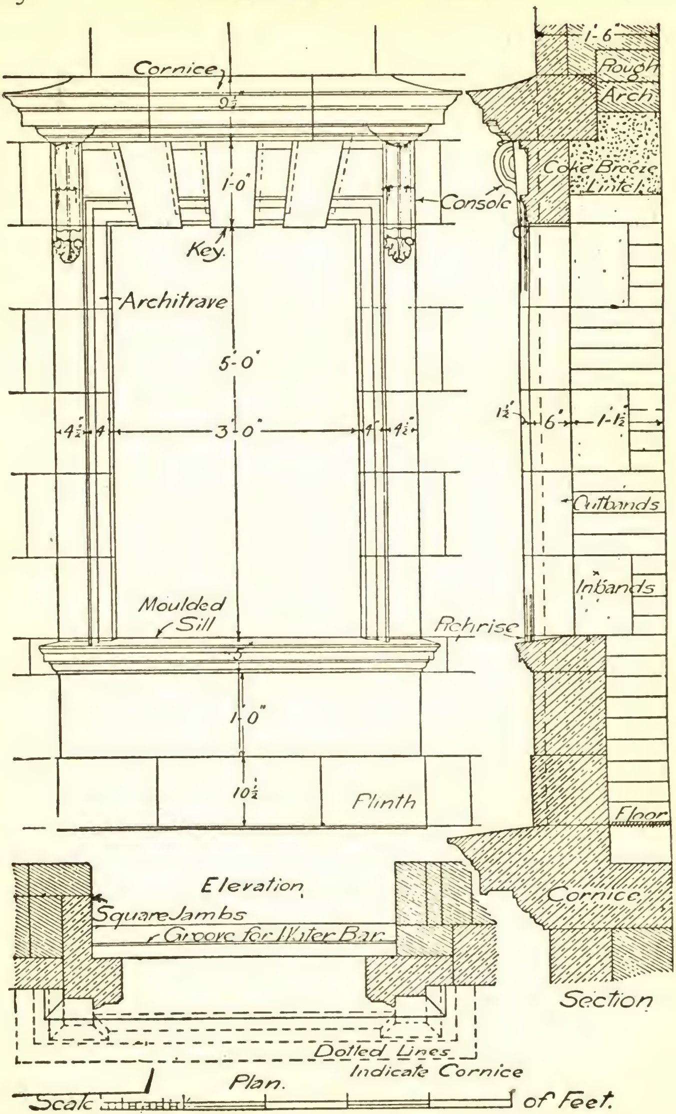


Fig. 102. Fig. 104. Fig. 105.

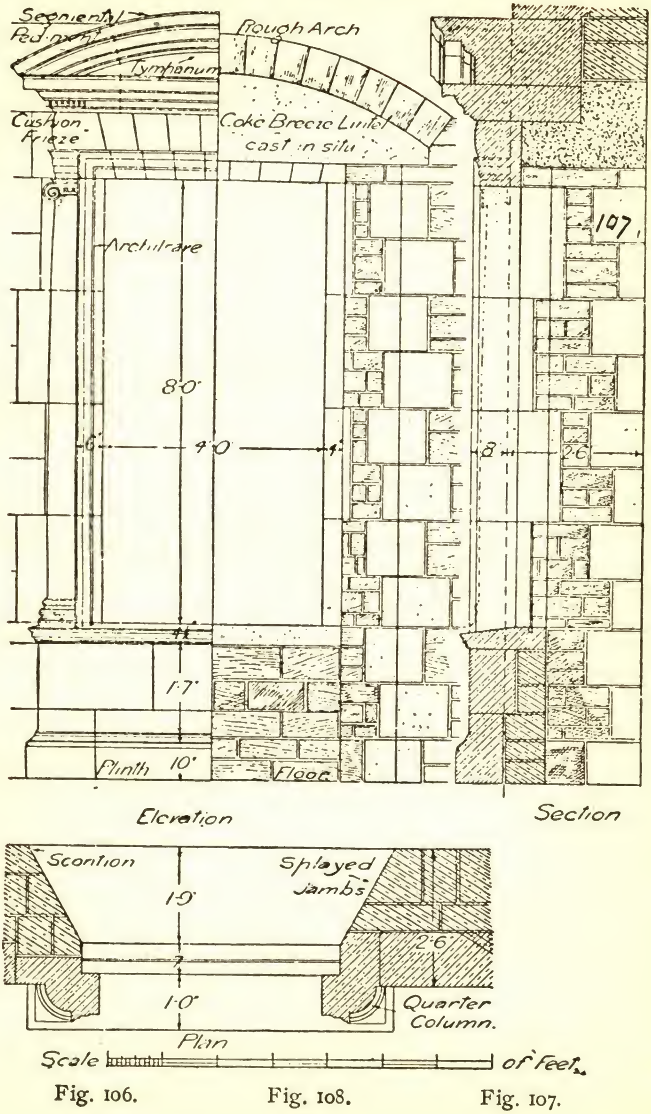
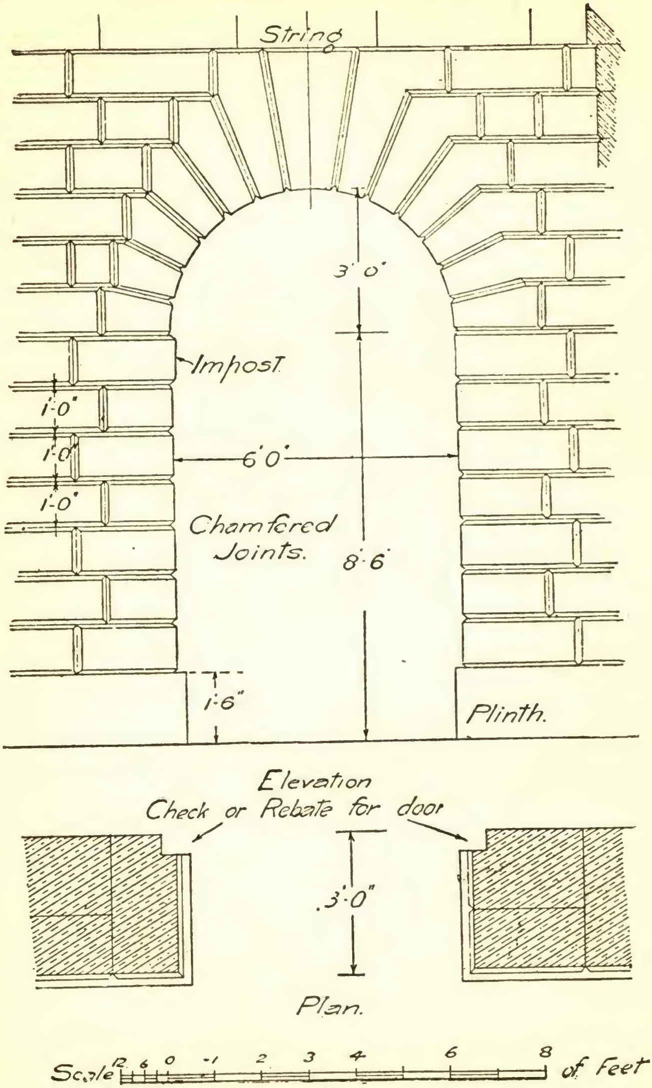


Fig. 106. Fig. 108. Fig. 107.



Figs. 109 and 110.

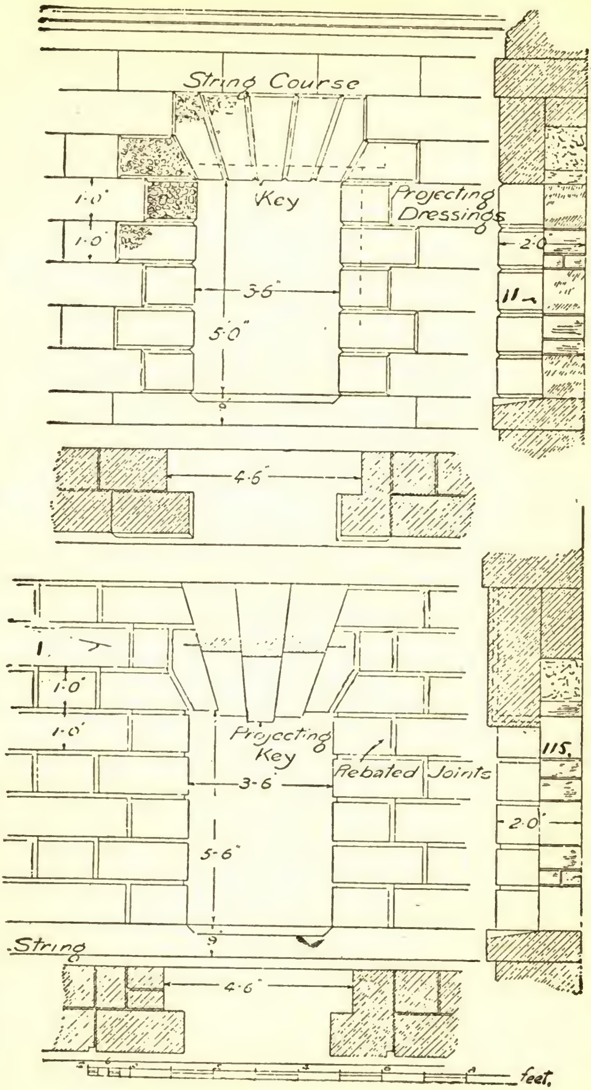


Fig. 111.

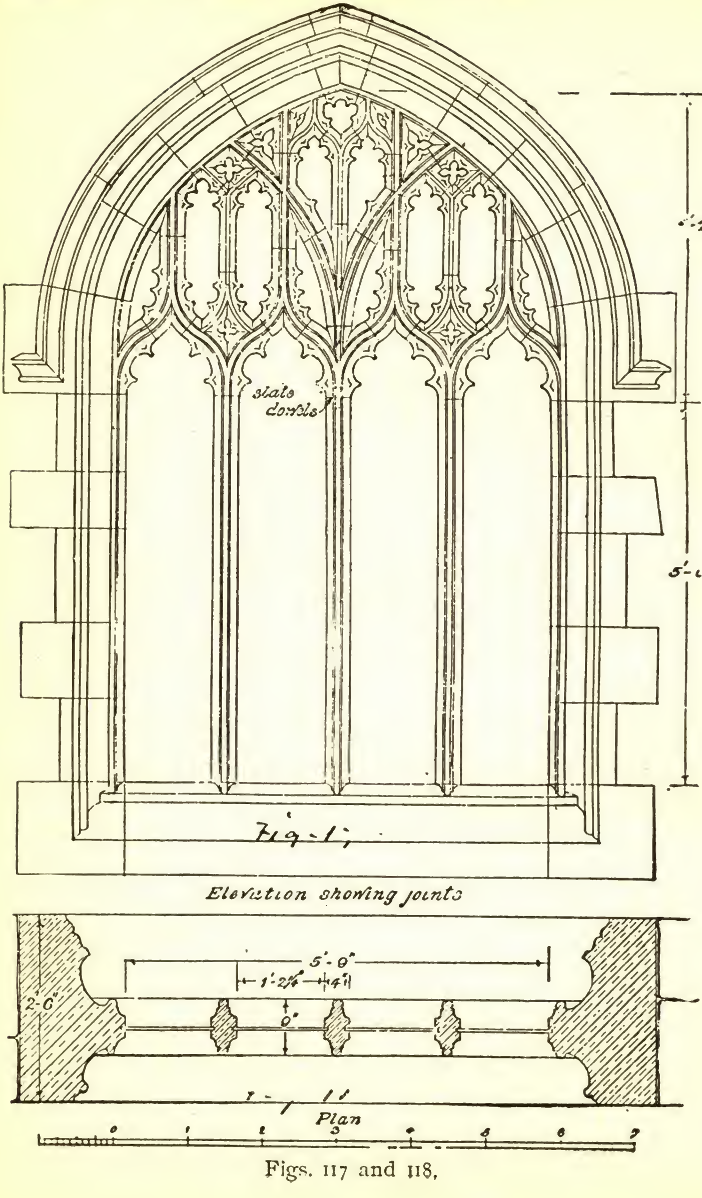
Fig. 112.

Fig. 113.

Fig 114.

Fig. 115.

Fig. 116.



Figs. 117 and 118.

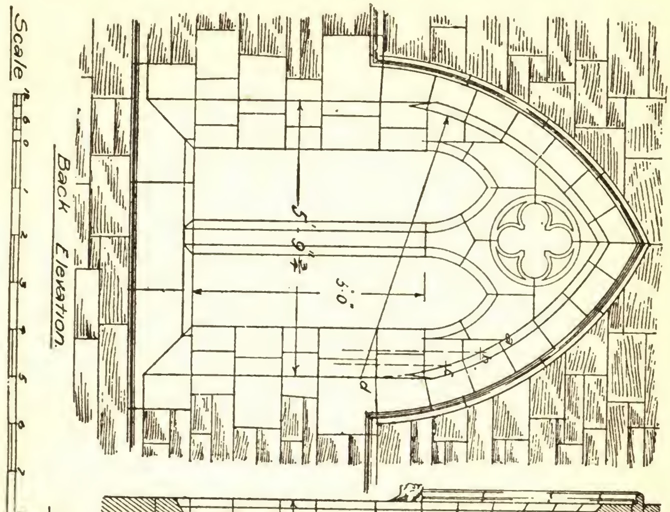


Fig. 119.

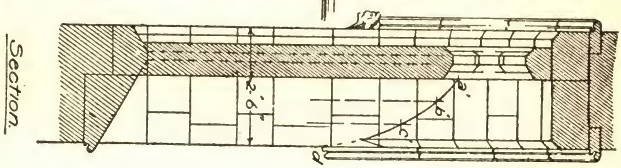
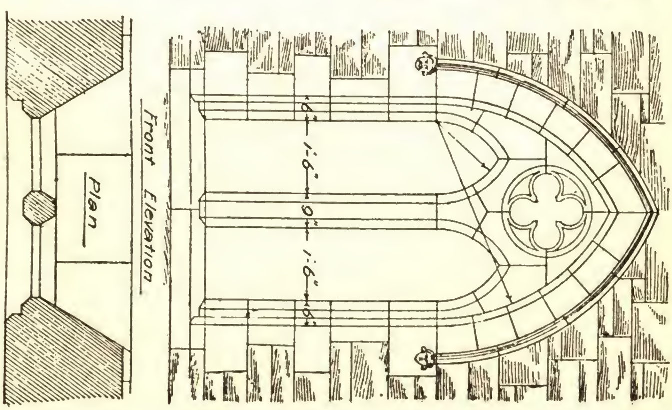
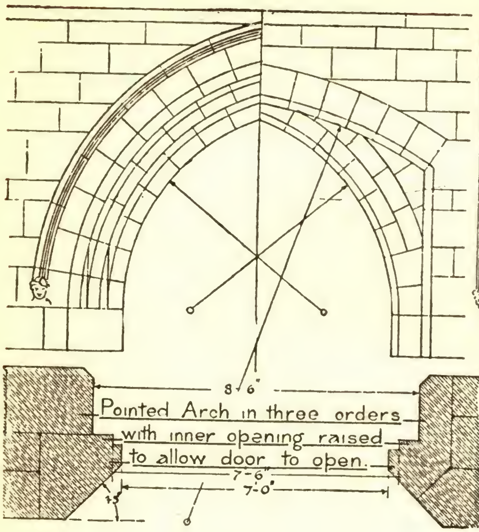


Fig. 120.



Figs. 121 and 122.

Fig. 123. Fig. 124.



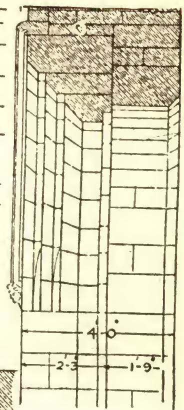


Fig. 125. Fig. 126.

the use of sconcheons. A coke breeze lintel case *in situ* is shown over the internal opening. Figs. 109 and 110 illustrate a semicircular opening in an ashlar wall, the blocks of which have chamfered joints. In these arches it is necessary to extend the bed joints of the voussoirs till they intersect the courses of the work; this results in the voussoirs gradually getting longer as they approach the key. Another method of arranging voussoirs is shown on right hand of Fig. 109. In this the bed joints of the voussoirs are extended to meet the horizontal courses, and are then returned a convenient distance along the horizontal course; this prevents the vertical joints of the voussoirs coming too close together near the springing.

Figs. 111 to 113 show a rectangular opening, spanned by an arch, the dressings and voussoirs of which project beyond the wall face about 1½ inches, have chamfered joints, and are vermiculated on surface to give importance to the opening; this form of opening is commonly adopted in the basement stories of classical buildings.

Figs. 114 to 116 show a similar opening, the voussoirs projecting as they approach the key and the joints of the masonry being rebated. This is also used for basement stories of classical buildings.

Stone being a granular material, anything approaching an acute angle is liable to weather badly; therefore in any tracery work, having several bars intersecting, a stone must be arranged to contain the intersections and a short length of each bar, as shown in Fig. 117, and the joints should be (*a*) at right angles to the directions of the abutting bars if straight, or (*b*) in the direction of a normal to any adjacent curved bar. This not only prevents any acute angles occurring, as would be the case if the joints were made along the line of intersection of the moulding, but also ensures a better finish, as the intersection line can be carved more neatly with the chisel, and is more lasting than would be the case if a mortar joint occurred along the above line. In no case, either in tracery, string courses, or other moulding, should a joint occur at any miter line (Fig. 118).

Figs. 119 to 122 illustrate the jointing and building up of a pointed arch with plate tracery and a rere-arch. Figs. 123 to 126, illustrate a pointed arch in three orders. with inner opening raised to allow door to open.

Tracery.—Wherever the moulded members of the

tracery admit of it, the practice should be followed of designing the tracery and fitting in rebated stone reveals, similar to the method of fixing wood frames in reveals, as it is found to be easier to fix the tracery after the opening is built.

STONE STAIRS AND STEPS

These consist of a number of blocks, fixed at regular and convenient heights, to facilitate transit between planes of different levels, and are of three kinds: (1) those stairs supported at both extremities; (2) those fixed at one end, (the other end being left free), and known as hanging steps; (3) steps circular in plan. These latter are divided into two classes: (1) those with a central newel; (2) those with an open well.

The steps may be in one of two forms, either rectangular or spandrel, as shown in Fig. 127. In the commoner stairs the rectangular blocks are used, but where a good appearance is desired or to gain head-room, spandrel steps are employed. The spandrel steps may be finished in one of three ways: (1) with a plain soffit, which consists in finishing the soffit in one plain surface, as shown in Fig. 127; (2) a broken soffit may be employed, as shown in Fig. 127; this is used for one of three reasons, or for all combined: (*a*) to gain strength at the back of the tread; (*b*) to save the expense incurred in working the surface of each step perfectly level; (*c*) to obtain effect; (3) having the soffit moulded.

Each step may simply rest upon the one below it, but it is usual for the upper step to be rebated over the back of the one below to prevent sliding. To avoid acute angles at this point, and to form an abut-

ting surface, particularly in the spandrel steps, a chamfer is taken off the top back edge of the lower step at right angles to the pitch of the stairs, the upper step having a corresponding sinking to fit. This is known as a back joint, and is shown in Fig. 127.

Fixing the Steps.—Stone stairs are erected in one of two ways: (1) they may be built in the walls as the latter are built, or (2) spaces may be left in the walls

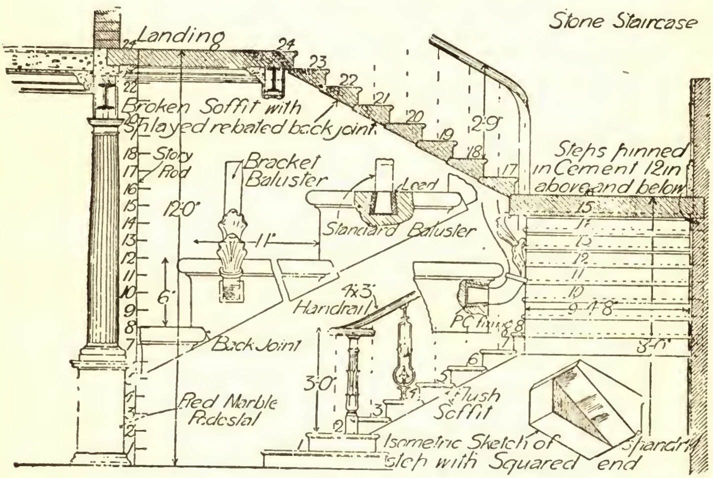


Fig. 127.

to receive the ends of the steps, which are fitted and fixed when the wall is finished. The wall should be built in cement mortar for at least 12 inches above and below the line of the stairs, the gaps to receive the stairs being temporarily filled up by brickwork bedded in sand.

The ends of the steps should be pinned in the walls with tiles or slates set in cement, care being taken that the space left about the end of the step is filled up, as

far as possible, with solid material, leaving no thick mortar joints to squeeze out. While the steps are setting, the outer or free end should be supported with wood struts, after being leveled, which should remain until the cement has thoroughly set.

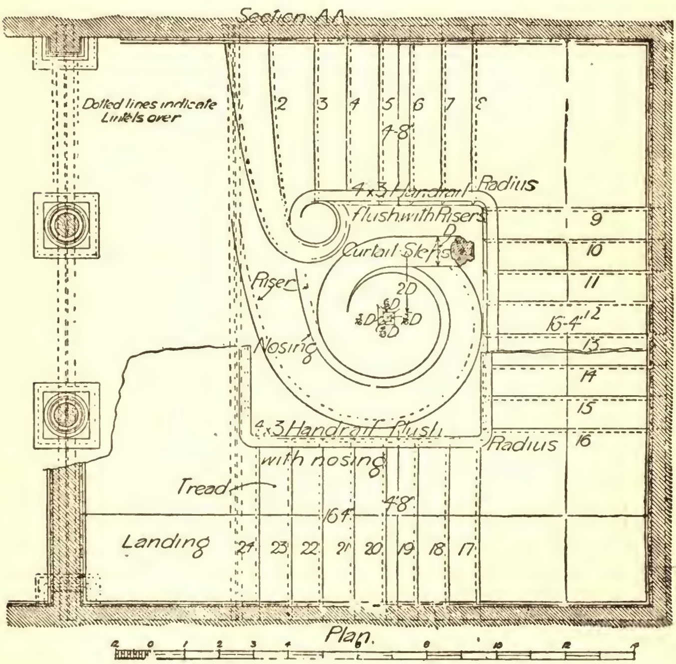


Fig. 128.

The first kind of stair, viz., those supported at both ends, combine convenience with the greatest strength. They are much used in schools, theaters, and other public buildings. They are usually made of rectangular steps, which rest six inches on the wall at either extremity.

The second kind, or hanging steps, are much superior in appearance to those last described. They derive their chief support from the walls, but each step receives an additional amount from the one directly beneath it. These are used for all conditions of stairs, from the secondary staircases in dwelling-houses to the grand staircases in public buildings. In the commoner kinds, rectangular steps are used; but in the superior, spandrel steps are always employed.

The steps may be plain or have moulded nosings; where the latter are employed, the moulding should be returned about the free end, the moulding on the latter being returned and stopped directly beneath the riser of the steps above, as shown in Fig. 127.

When the staircases are very wide, it is advisable to support the steps at their outer ends by steel joists or cantilevers at intervals, the strength of stone under cross stress not being very great. Fig. 127 shows a landing supported by a joist.

The first of the third class of stair, the circular newel, is used for turret steps; they are built in a circular chamber. The steps are wedge-shaped, their thin end being worked circular to a radius of about 3 inches, the front edge of each step being tangent to this circle, the back edge of the step being a radial line. The steps are built into the walls of the chamber, at their wide ends, each of the circular ends being arranged to fall directly over the one beneath it, thus forming a continuous newel up the center. These form a strong stair, but are rather dangerous, as they have to be steeply pitched to gain the necessary head-room.

Secondly, those formed with an open well are built in the same manner as the hanging stair, of which they form one variety. Stairs, circular and elliptical in

plan, are often built between two walls, as in the first class of stair.

Large stone landings which cannot be obtained out of one piece of stone are joggled at their joints, and where the slabs are thin and are likely to be subjected to heavy traffic, should be supported by steel girders.

The balusters in stone staircases are always of iron, which is better for fixing purposes. There are two methods of fixing balusters: (1) fixing them into the top, suitable for standard balusters, as shown in Fig. 127; (2) fixing them into the side, when they are termed bracket balusters, as shown in Fig 127. Holes are bored in the steps at the proper intervals, being slightly undercut. The ends of the balusters are indented before being inserted; they may be fixed in with lead, Portland cement, sulphur, and sand, or asphalt, as previously described.

Figs. 127 and 128 show plan, elevation, and details for an open well hanging stair, built of good hard stone. The lower flight shows handrail supported by standard balusters, the upper portion with bracket balusters to obtain the maximum quantity of available stair space. The method of setting out a scroll and curtail step is shown.

Stone Roof.—Fig. 129 shows the method of forming a stone-covered roof over a vaulted chamber, such as was frequently used during medieval times in military and monumental buildings. It is formed of stone flags bedded on rubble filling over the vault. In these roofs the flags are laid in two systems, the lower and the upper; in the first the flags are spaced apart, in the second the flags are bedded with a lap of 2 or 3 inches over the top edges of the flags in the first system. The whole upper surface has a slight fall for drainage.

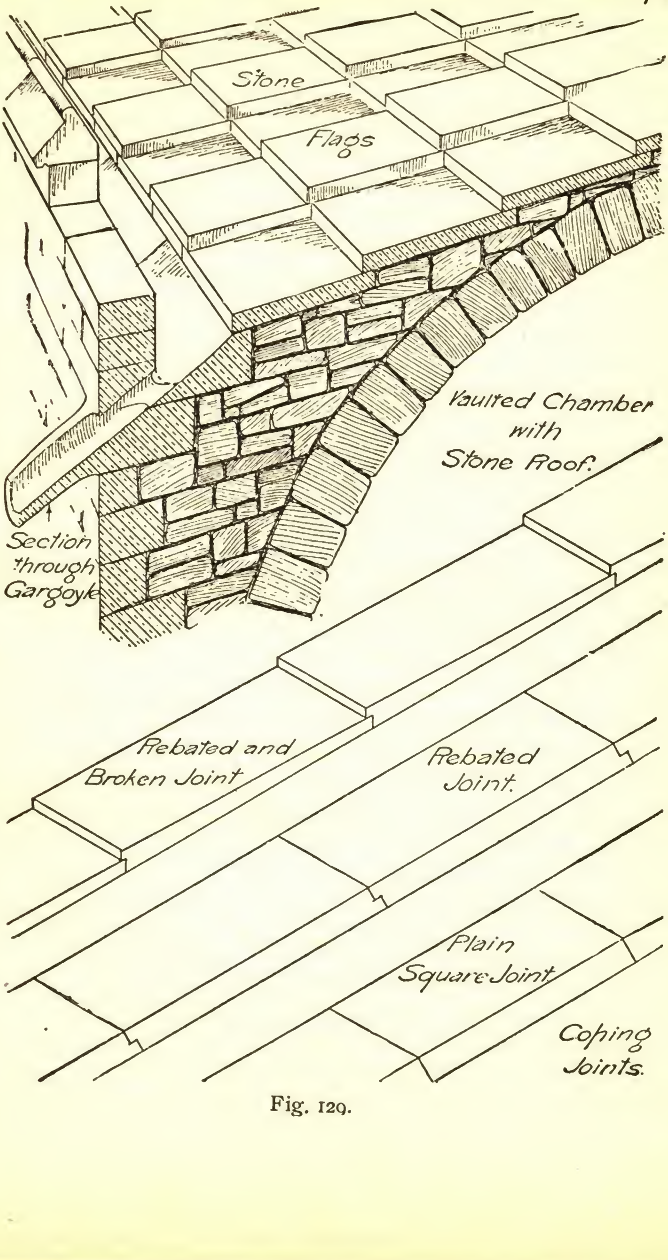

Stone
Flags
Vaulted Chamber with Stone Roof.
Section through Gargoyle
Rebated and Broken Joint
Rebated Joint.
Plain Square Joint
Coping Joints.

Fig. 129.

Mouldings.—Mouldings may be classified under two heads, Classic and Gothic. The Classic are those derived from those employed by the Greeks and the Romans Invariably the Roman mouldings are found to have their prototype in the Grecian examples, the chief difference being that the Greek are either segments of some of the conic curves or are struck freehand, while the Roman curves are all segments of circles (Figs. 130 to 138).

There are nine typical examples, as follows:

1. Fillet.—This is a narrow, flat projection, often used to divide individual mouldings or groups of mouldings in any composition; it is similar in both Greek and Roman work, as shown in Fig. 134.

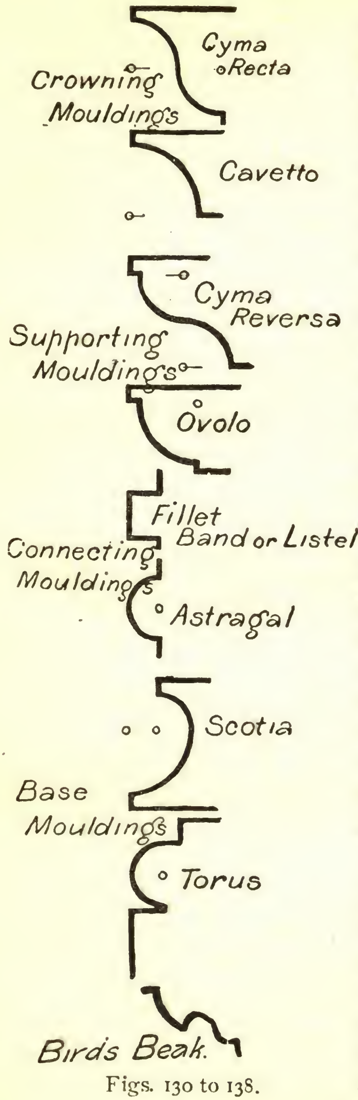
2. Astragal is a small semicircular moulding, as shown, often used in combinations of mouldings, but chiefly to mark the division between the shafts and caps of columns. This member is similar in Greek and Roman.

3. Cavetto.—The cavetto is a hollow moulding, consisting in the Greek of a quarter of an ellipse and in the Roman of a quadrant.

4. Ovolo.—This moulding in the Greek consists of a segment of an inclined ellipse, having a fillet at the top and bottom, and forming at the top a quirk. In Roman work it is a quarter circle, bounded at top and bottom by a fillet.

5. Cyma Recta.—This is a double curve, formed in the Greek of two quarter ellipses whose minor axes are in the same straight line and bounded top and bottom by a fillet. The Roman example is similar, but consisting of two quarter circles. This moulding has a concave portion of its surface above the convex, and is generally used as a crowning member.

6. Cyma Reversa, as its name implies, is the reverse of



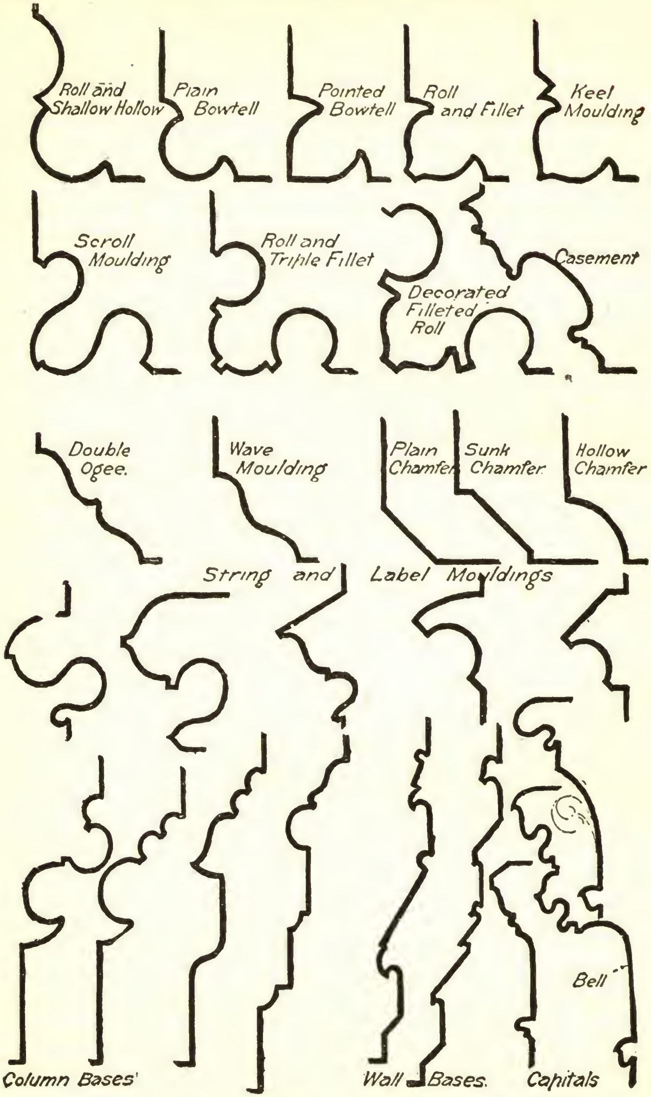
Figs. 130 to 138.

the preceding moulding, slightly modified in the Greek by having a quirk above, between the same and the fillet, and the hollow portion slightly more concave. The Roman is an exact reverse.

7. *Scotia.*—The scotia in the case of the Greek is formed of an inclined ellipse, having a fillet above and below. The Roman is struck from two centers on a common radial line.

8. *Torus.*—The torus is a base moulding, the Greek form being the reverse of the scotia. Many Greek examples are, however, similar to the Roman, consisting simply of a large semicircle with a quirk below and fillet above.

9. *Bird's Beak.* — This moulding only occurs in the Greek mouldings; it consists of a quarter ellipse, with the major axis horizontal, in the lower side of which a small hollow has



Types of Gothic Mouldings.
Figs. 159 to 165.

been worked, and is used as a supporting moulding.

In the designing of groups of mouldings for cornices, strings, etc., reference should be made to the suitability of the forms for their intended position, and for this purpose they may be divided into base mouldings, connecting mouldings, supporting mouldings, and crowning mouldings. The base mouldings would include such mouldings as the torus, the scotia or the inverted cyma recta, and any combination of such mouldings that would tend to broaden the base and distribute the weight of the mass supported.

Connecting.—These include the fillet and the astragal.

Supporting.—The supporting mouldings include such members as the ovolo, bird's beak and the cyma reversa, mouldings that do not have their hollow members near their upper edge, and such as have their mass in a position to strengthen them, and are fitted to act as corbels. These mouldings are used to form the bed mouldings or lower parts of combinations, such as cornices which are divided into two parts, the bed mouldings and the crowning mouldings.

Crowning Mouldings are those mouldings which are not expected to carry anything above, such as the cyma recta and the cavetto, the top members of which are small and delicate.

The above ideas are not always rigidly adhered to, and successful departure from them is often made with good effect; but it is prudent to bear these principles in mind when designing any groups, for if too widely departed from, confusion ensues.

Gothic Mouldings.—Figs. 139 to 165 give a selection of the mouldings commonly used in the Gothic periods, combinations in archivolts, also for strings, wall bases, bases and capitals of columns.

SPECIFICATION CLAUSES

MATERIALS

STONE

1. The whole of the stone to be of the best description of its respective kind, and to be free from sand holes, vents, flaws, and all other defects. Should it be disapproved it shall be removed at once from the site.

2. Any stone which will not sustain a load under test of 2-in. cubes equal to..........lb. per sq. in. may be rejected and the contractor is to furnish to the architect, if demanded, fair cut cubes taken from any stone challenged by the architect, and the test of such cubes shall be considered a test for all the stone of a similar character.

3. The...................stone is to be obtained from the quarry of................... to be equal in all respects to sample blocks deposited with the architect, and approved by him in writing.

NOTE.—This clause should be repeated for each different stone to be employed in the building, to prevent the substitution of an inferior material. In no case should an architect specify particular stone by a general trade name. In the case of sandstone for sills, hearths, etc., the following clause may be used.

4. The stone is to be of an approved quarry, and the contractor is to deposit samples of the stone he proposes using with the architect, and obtain his approval in writing before ordering same.

5. All cut stone work of every description, including window and door sills, caps, corbels, cornices, steps, railings, brackets, balcony floors, chimney caps, copings, fireplace lintels to be cut as per plans, details, etc., for the same, and to be delivered at the building properly fitted and with all necessary lewising and drilling for anchors by the stonecutter.

6. Any stone found at completion to be broken or defective is to be cut out and replaced by the contractor.

MATERIALS FOR OTHER TRADES

FOR "DRAINLAYER" (HOUSE DRAINAGE)

7. Provide good stone covers for air inlet chambers, 2 ft. 9 in. by 2 ft. 9 in. by 4 in. thick, finely tooled on top and edges, with rebated perforation for cast-iron hinged grating in frame.

8. Provide good stone covers 3 ft. by 3 ft. by 4 in. thick, for partially covering manholes, as shown on drawings, with circular perforation, 1 ft. 9 in. in diameter, for entrance.

9. Provide stone covers, 2 ft. by 2 ft. by 4 in. thick, for tops of lamphole shaft, terminating in roads or carriageways, with perforation the full diameter of the top of the pipe. The covers to be finely tooled on the top and edges, and to have 3 in. block letters "L. H." cut in on the surface.

10. Provide for inspection junctions stone covers, 18 in. by 18 in. by 3 in. thick, finely tooled on top and four edges to have 3-in. block letters "I. J." cut in on the surface.

11. Provide for the cleaning eyes stone covers, 18 in. by 18 in. by 3 in. thick, finely tooled on the top and four edges, to have 3-in. block letters "C. E." cut in on the surface.

FOR "MECHANICAL ENGINEER"

12. The cover for engine bed to be of..........stone, 16 in. thick, with chamfered edges, holed through in four places for holding down bolts, all as shown on drawings.

13. The coping for walls of flywheel race to be 9 in. by 6 in. ....stone boasted coping.

14. The flag cover for boiler sides and flues to be 3-in. hard ....stone flags with boasted overhanging edge.

15. The coping for blow-off pit to be 9 in. by 6 in........... stone boasted coping rebated for iron plates.

WORKMANSHIP—GENERAL WORK

16. All stone work to be set in best manner, every stone well bedded with complete full squeezed out joints in cement mortar, and all work in contact with brick to be plastered with similar cement to protect from stains, and all the brick backing of same to be set in similar cement mortar.

17. All stones to be well wetted before setting, and large stones to be set with a derrick Rake out mortar joints when setting.

18. The joints between cut stone blocks in all columns or whereever any weight is brought on any cut stone work to be made with 5-lb. sheet lead worked back from the face 2 in., the center being cut out to allow space for settlement.

19. No angle miters will be allowed in any part of the work.

20. All window sills and all belts forming window sills to be in one stone each if desired by the architect.

21. The lines of all mouldings, curves, angles or miters to be worked to their true and proper forms, and all returns of miters of mouldings, washes or bevels to be worked on and out of the solid. The beds and joints of all stonework to be square with the face.

22. All rebates for frames to be cut in the stone joints according to plans and directions of the architects. All the windows or other finish of stone to be in size and form as shown on detail drawings, moulded, etc., according to the details of each part.

23. All stonework to be jointed as shown or directed.

24. Fix in all joints, where shown on details or as directed, copper dowels (provided by "coppersmith"), tailing equally into each stone, and run with oil cement. No iron dowels, galvanized or otherwise, will be allowed, and if brought on the job shall be returned immediately.

25. Carefully perform all cuttings and dowelings of holes for iron railings, crestings, bars, anchors, etc. Also all cutting for all galvanized iron, tin and lead flashing to the several roofs and wherever else required.

26. Chases to be left in all walls where shown on drawings, or wherever required for the running of steam, gas, and water pipes, or for any other purposes which may be found to be necessary after the work has been built.

Cut chases and break out holes for steam, water and gas pipes, or for any other purpose.

27. The front entrance to have ..in. by ..in.........stone rubbed top and front, and back-jointed step with sunk and moulded front, and with short returned sunk and moulded ends.

The tradesmen's entrance to have ..in. by ..in. good free stone, tooled top and front, and back-jointed step.

All steps to be kept up 2 in. above floor to allow for thickness of mat.

The doorways to.. ....to have..in. sound, free stone

rubbed, and back-jointed both edges, thresholds the full widths of the walls.

All steps and thresholds to have mortises for dowels of door frames.

28. To be of..........stone 14 in. by 6 in., wrought, sunk, weathered, throated, and rubbed on all exposed parts, including the soffit of the projection, grooved for metal tongues, and set in mortar.

All to have proper stools for jambs.

29. Finish the parapet next..........with 14 in. by 6 in. suitable stone rubbed saddle-backed, double-moulded (to detail), and double-throated coping, with kneelers, springers, bonders, etc., of the sizes shown.

Finish the parapet over............with 13 in. by 3 in. suitable stone, tooled and weathered coping throated on both edges.

All copings to have lead-plugged joints.

NOTE.—Iron should not in any case be used as cramps. Should cramps be preferred to lead plugs, copper or gun metal should be used.

30. Carefully bed and dowel all cornices in cement mortar.

31. The heads to windows where shown to be stone to be of ....stone stop, moulded to detail of the sizes shown, and 6 in. longer each end than the width of the opening.

32. The staircase from ground floor to basement to have..in. by ..in. tooled all round threads, and ..in. by ..in. tooled all round risers.

The staircase from ground floor to..........to have ..in. by ..in. rubbed all round............stone spandril steps, splay rebated and splay back jointed with sunk and moulded fronts with solid square wall ends. The other ends to be returned and moulded to match fronts.

The bottom step to be solid with curtailed end as of the size shown.

The landings to be..in. thick, sunk and moulded on free edges to match steps with cement-plugged joints. Fill in between landing and steps below same with ..in. by ..in. splay rebate and splay back-jointed filling-in piece with fine rubbed joint.

All ends of steps and edges of landings next walls to be built in at least 4½ in.

33. Properly cut and pin, or build in the walls, all ends of steps, edges of landings, etc., requiring it.

34. Put 4 in. rough..........stone corbels under all overhanging chimney breasts.

35. Turn relieving arches of such span as may be directed in walls over weak spots in the foundations or over openings.

36. Put under ends of rolled joists up to ..in. by ..in., 14 in. by 9 in. by 3 in., under ends of larger rolled joists 14 in. by 14 in. by 4 in., and under ends of riveted girders 18 in. by 14 in. by 6 in. ....stone templates, finely tooled for iron, and with tooled edges where exposed.

37. The columns and stanchions to have 21 in. by 21 in. by 6 in. ....stone bases finely tooled for iron and mortised for lugs.

NOTE.—The columns and stanchions to be slightly wedged up with steel wedges, and run in with neat cement.

38. Chimney stacks to be worked according to detail drawings and properly cramped as directed. The top stone of chimneys where possible to be in one stone with holes cut through for flues.

39. All rolled joists and girders carrying walls to have 3 in. stone tooled covers with coped edges bedded in cement.

All riveted girders to have bed of cement on top of same to cover rivet heads.

40. Put 3 in. rough stone flags bedded and jointed in cement as cover to dry area.

41. The curb to area outside............to be 9 in. by 6 in. ....stone tooled all round with cement-plugged joints.

The curb to area outside..........to be similar, but rebated for pavement lights.

42. The kitchen and scullery fireplaces to have 2½-in. stone rubbed front and back hearths.

The remaining fireplaces where stone hearths are shown to have 2 in.........stone rubbed front and back hearths.

All to be 12 in. longer than the width of opening and 18 in. projection, except to kitchen, which is to be 24 in. projection.

43. The kitchen chimneypiece to have 7½ in by 2 in......... stone rubbed jambs, and 9 in. by 2 in..........stone mantel and shelf. The shelf to project 6 in.........each end beyond mantel, with rounded corners, and to be supported on 12 in. by 6 in. by 2 in. rubbed and moulded stone corbels cut and pinned in wall.

44. Provide and fix..........stone rubbed and dished sink in

scullery 3 ft. by 1 ft. 8 in. by 5 in., all in clear, the bottom to fall and holed for grating.

NOTE.—Glazed stoneware sinks are generally preferable to stone, except in special cases.

45. Provide and fix as shown a 4 in. chamfered and holed top to copper, to be in one slab of rubbed..........stone.

46. Cut all grooves and rebates as may be required for glazing, etc., up the jambs and mullions, and in the tracery, and well point upon both sides with coarse putty.

47. Form rebates for iron casement frames, and provide plugs and holes in stone to each.

48. Mortise steps, sills, etc., for tenons of door frame shoes, and run in the tenons with lead.

49. Each bell pull at entrances to be let into a stone 9 in. by 9 in. by 9 in., set in cement and sand, sunk for pull, and mortised for wire.

50. Cut proper mortises in the stone for the ends of all saddle bars, stanchions, etc., and run in with cement; properly let in and run with lead all double fangs of hinges, staples, catches, sockets, etc., as may be required.

51. All works intended for carving to be prepared by the mason, and all boasting necessary to be done by him, great care being taken to leave sufficient stuff to give the carver plenty of scope. The carving to be done by professional carvers approved of by the architects, and according to detail drawings to be furnished. Carving to be done either on the ground or in position after the building is up, as directed by the architects.

52. Provide and allow for selecting a specially jointed foundation stone and for cutting inscription on same of about........ letters 2 in. high, and cutting a cavity in same, and provide an air-tight solid copper box to hold papers, etc., to be deposited in same, and allow for extra labor and materials in setting stone with usual ceremonies. Also provide and allow for clearing up the parts of the building near the stone on the day appointed by the building owner, and making the premises clear and safe and available for the usual assembly and allow for interruption of such work as necessary.

53. Thoroughly clean down all work at completion and clean out and point all joints in cement, tinted to match stone, well tucked into joints and finish with a neat flat surface.

54. Lime whiten all exterior wall surfaces, mouldings, etc.

SPECIAL CLAUSES FOR A CHURCH

LABORERS

55. The whole of the stone to be of the best description of its respective kind, to the architect's approval; to be free from sand holes, vents and all other defects; to be worked to lie on its natural bed when set, and to be bedded and jointed, except where otherwise described, in mortar (or putty), with wide (or fine) joints, which are intended to show.

All the stone is to be worked on the site, and particular care is to be taken to preserve all the joints of the stonework from the irregular appearance which is caused by the arrises being broken before the stones are set. No work thus injured will be allowed to be used, and no patching will be allowed. The stonework to be so truly worked as not to require any cleaning off beyond washing.

56. All the dressings (unless otherwise described) to be finished off with a fine drag (or a chiselled face or rubbed) in a manner to be approved by the architect, and to be bonded and fixed in the most substantial manner.

57. The vertical joints of sills, parapets, cornices, and all joints in tracery of windows, in vaulting ribs and chimney caps, are to have double cement plugs and mortises for same, or double V-grooved joints run with cement as may be necessary.

58. The mullions, copings, jamb shafts, pinnacles, and such are to have 1 in. or $1\frac{1}{4}$ in cube slate dowels (as required) to every stone in the bed, run with cement, with proper mortises for the same

DRESSINGS

59. The external dressings of windows and doorways, also the copings, strings, gable crosses, weather courses, weatherings, etc., etc., are to be executed in........... All external angles of dressed stonework to be worked in the solid.

60. Provide and fix hinge and lock stones as shown on the drawings and as required. (It is sometimes advisable to make these stones of a harder material than the dressings.)

61. The internal dressings, unless otherwise described, are to be of.........., finished with finely-rubbed faces.

62. All internal angles of dressed stonework to be worked in the solid.

63. The detached piers and springers over same are to be exe-

cuted in..........stone. Internal detached shafts to be of ....stone (or marble, etc., etc.) as required, the whole to have circular, finely-dragged faces, or to be chiseled (or rubbed), the top and bottom beds to have mortises run with cement, and the intermediate joints to have light copper cramps as may be directed.

ASHLAR

64. The internal facing throughout to be of........stone ashlar. The external facing is to be of........stone ashlar. The courses are to be of various heights (averaging 6 in. on the bed) from 4 in. to 10 in., and to line generally with the beds of dressed stonework. They must also be properly bedded and bonded into the body of the walls. Each stone must be set in mortar, cut, and properly fitted up to the dressings, arches, etc., and be finished with a finely-dragged or chiseled face.

VAULTING

65. The springers of the vaulting must be worked on the solid as shown on detail drawings; they and the wall ribs are to be built into the walls as the work proceeds, but those portions of the groin ribs which are fully developed on the springers, as well as all the filling in, will have to be set after the roof is up and covered in. The contractor is to allow for any extra scaffolding, labor, etc., that may consequently be required.

66. The cells of vaulting are to be filled in with........stone 4 in. thick in narrow courses built in mortar, the soffits to be slightly arched or cambered, and the surface to be finely dragged or chiseled to match the internal ashlaring, etc.; it is to be cleaned off and the joints struck as the work proceeds, to be properly cut up to the stone ribs, and to have all necessary centering or laths that may be required for the support of the cells whilst building.

SUNDRIES

67. The gable crosses to be of........stone worked according to the drawings, and fixed with 3 in. by 1 in. by 1 in. slate dowels run with cement.

68. The masonry in all towers to be built with special care with large flat stones, carefully bedded, each stone to break joint over the center of the stone below. Not more than........stones to be placed in the width of the wall set in mortar and grouted as described for the other portions of the work. All joints to be

true and close, filling in the walls with spalls will not be allowed.

69. The tops of the turret and chimney stack are to be built as shown on the drawings, the top and cap stones of turrets and the top stone of chimney to be solid and perforated for the flues and finial rods as required.

70. A weather course to be fixed round chimney stack, also on ...., all with solid springers, apex, and bond stones about 4 ft. apart. (Some prefer to work these entirely on the solid.)

71. The chimney-piece in vestry to be formed in............ stone, as shown by the detail drawing, and to be properly doweled together and tied with copper cramps into the walls. The fender to be of stone, 3½ by 3½ in., rubbed and moulded, with dowels and cement plugs as required, and to have circular corners as shown by the drawings.

72. The seats in sedilia, the bottom of piscina, etc., to be also of..........stone, all of the widths and thicknesses shown.

FLOORS AND STEPS

73. The altar stone to be a 6 in. rubbed..........slab in one stone, and of the size of the altar as shown.

74. The steps within the chancel and at the entrances thereto are to be of the best selected..........stone, rubbed top and front and back-jointed; to be in long lengths with fine joints and double cement plugs in same, and of the sizes shown; all to be bedded hollow on brickwork. Similar steps to be fixed........

75. The heating vault and........to have 2½ in. tooled...... paving in mortar.

CARVING

76. Provide models to the approbation of the architect, made by an artist, for the whole of the carving; the whole to be made to a scale of 3 in. to 1 ft.

77. Perform in an artistic manner to the satisfaction of the architect, the carving of the pendants, battlements, foliated arches, finials, crests, small domes, and of every other part of the building.

Note.—It is more often the custom in the best work to insert a provision for the carving of a building, such sum to include cost of making necessary models.

78. Clean down the masonry work and generally leave the

whole perfect and complete, omitting no material or workmanship either described or implied by the drawings and this specification, or that is necessary to render the whole complete in every respect.

NOTE.—Many architects will not allow any cleaning down. There is little doubt but that the custom is injurious to some stones, as it removes the natural case-hardened weather-face.

SPECIAL CLAUSES FOR A BUILDING IN A STONE DISTRICT

79. The stone for wallings, footings, and dressings generally to be obtained from..........quarry. (If the quarry belongs to the building owner, insert the following:—No royalty will be charged, but the contractor will have to quarry the stone and convey it to the building. The quarry to be left in good order at completion.) Stone for sills, mullions, transoms, string courses, cornices, copings, weatherings, and other exposed positions to be obtained from the............quarry belonging to Mr.......... The whole of the stone to be set so as to lie on its natural quarry bed.

80. Build the footings with large flat-bedded rubble walling stones, specially selected for the purpose, in mortar thoroughly bonded, bedded perfectly level, filled in solidly, and flushed up with mortar.

Properly lay up the cellar walls with good hard flat building stone........in. thick, firm built and well bonded with a thorough stone at least in every yard super., laid in clean lime and cement mortar in parts of one of cement and two of lime, laid by and full to a line on both faces and flush and point at completion. Lay down in like manner substantial foundations under all chimneys, piers, and exterior steps, and all clear of frost. Leave all openings in walls for drain, gas and water pipes, as directed or as shown on plans.

81. The walls to be carried up in roughly-chiseled ashlar in mortar, to be thoroughly bonded and packed, and well flushed up with mortar and small stones.

82. The inside face to be carried up true and even in brickwork to receive plaster (4½ in. lining properly bonded with headers into wall).

83. The outside surface to be executed in roughly-chiseled

ashlar (the local rubble stone in horizontal random courses to average 7 in. on bed with one bond stone at least to every yd. super., the beds to be roughly hammer dressed, and the surface to be chopped to remove any great irregularity as shall be directed, the courses to vary from (3 in.) to (7 in.) high, and in stones between (14 in.) and (24 in.) long with occasional large square stone). The pointing to be done as the work is carried up by passing the point of the trowel over the joint, so that the mortar shall in no case project over any portion of the stones, and the joints to be slightly weathered.

84. The quoins to be got out of the best local weather stone, to be long each way on the bed, and well bonded into rubble walling, the angles to be truly formed, and the surface to be axed with irregular upright and diagonal strokes as shall be approved, or, if of rubble, "the quoins to be executed in selected large stones."

85. Provide for covering the tops of walls with asphalted felt if they should be uncovered during frost or very wet weather.

APPENDIX

In order to make this book as useful as possible I have thought it proper to add this Appendix to it, which, in my opinion, offers the best and most simple solutions to the problems discussed in this department. It is taken from the works of Wm. R. Purchase, one of the best known authorities on Cut Stone Masonry. The subjects dealt with are of the most difficult kind known to the art of masonry, but here they are reduced to the simplest manner possible, and the rules are made so plain that any ordinary workman should be able to thoroughly understand them.

ARCHES

CIRCULAR ON PLAN, OR ARCHES OF DOUBLE CURVATURE

To describe the construction of a Semi-circular Arch in a Cylindrical Wall, the development of which on convex or outside face is a semi-circle, and on concave or inside face is a semi-ellipse, the soffit radiating to a center at springing, and the crown of the arch level or at right angles to the vertical face of the wall.

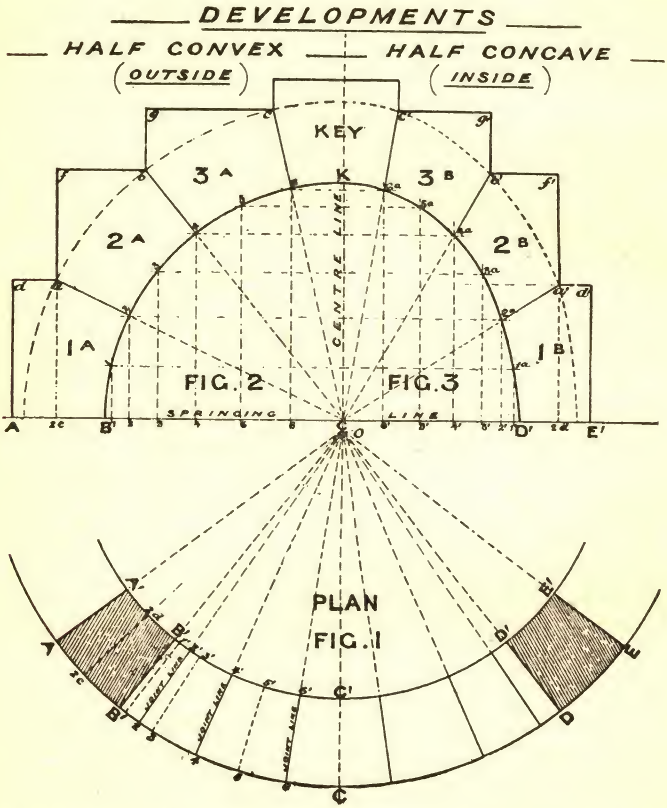
Fig. 1.—Shows plan of the arch, B C D being the opening, the arch radiating to O, the center of the cylinder.

To set up the Elevation on the Development for the Face Moulds.

Fig. 2.—Develop the segment A B C of convex face (Fig. 1), setting out the length on springing line as A B C from C as the center; erect a perpendicular as center line, and describe with C B as radius half of the semi-circle. Set off the joints radiating to the center C corresponding to the number of arch joints required, which in this example is seven. The square bonding *d a*, *f b*, *g c* of vertical and horizontal joints may be of varied sizes. The radiating joints (here shown) are made equal in length from the soffit, and for this purpose from the center C describe a quadrant, cutting the joints at *a b c*.

To find the Development of Concave Face.

Fig. 3.—Divide the quadrant B K (Fig. 2) into any number of equal parts—in this example seven—and draw the ordinates 1, 2, 3, 4, 5, 6, projecting the same on to the springing line, and transfer these to the segment line B C on plan (Fig. 1) as 1, 2,



3, 4, 5, 6, and from these points draw radiating lines from the center O, cutting the segment B′ C′ at 1′, 2′, 3′, 4′, 5′, 6′; draw the developed length of B′ C′ on springing line (which is also equal to C′ D′ and is half of the inside face) from C to D′; transfer

1′, 2′, 3′, 4′, 5′, 6′ from Fig. 1, and draw the ordinates of equal height to those of Fig. 2, cutting Fig. 3 at 1^a, 2^a, 3^a, 4^a, etc., through the points 1^a, 2^a, 3^a, 4^a, etc.; draw the half of semi-ellipse, which gives the curve of the arris to the soffit.

The length of the joints in Fig. 3 is determined in the same manner as in Fig. 2—namely, by means of ordinates. One joint is here given as an example:

From A No. 2 A (Fig. 2) drop a perpendicular cutting the springing line at 2 C; and from 2 C to 2 transfer to 2 C and 2 on the segment line of plan (Fig. 1), and draw radiating lines from 2 C to the center O, cutting the segment A′ C′ at 2 *d;* transfer the distance from 2 *d* to 2′ on to the springing line (Fig. 3). Set up ordinate and make equal in height to *a* on Fig. 2, and from 2 A to A′ (Fig. 3) draw joint line, which also radiates from the center C.

The moulds required for working each arch block are a bed mould and two face moulds (one to the convex and one to the concave face); these are already set out on plan and in developed elevations, but now require separating.

As an example, No. 1 A (Fig. 2) is the springer. For the bed mould take A B 2 and A′ B′ 2′ from plan (Fig. 1), and transfer to 1 C (Fig. 4).

The dotted line B B′ shows the line of the soffit on the bottom bed, the line *a a′* the line of the arch joint on the top bed, A A′ the line of radiating vertical joint, and 2 2′ the line of arris of the arch joint. This gives the plan of a segment of a hollow cylinder to the extreme size of the stone.

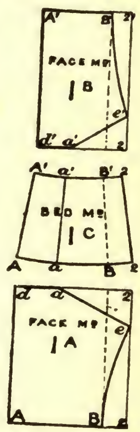


Fig. 4.

No. 1 A (Fig. 4) is the face mould for convex face, No. 1 B (Fig. 4) is the face mould for concave face, and both of these are transferred from 1 A and 1 B (Figs. 2 and 3), with the addition of the square line 2 2 and 2′ 2′.

The stone for the arch block should be large enough to work the bed mould square through; if there is a "wanty" corner in the rough block, this may be arranged for in the corner where the stone has to be cut away for the soffit or the top joint.

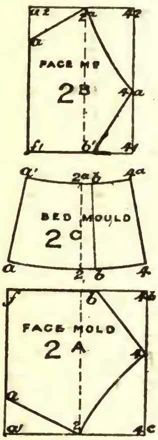
Work the two beds bottom and top parallel to each other and of the height of the face mould, scribe in the bed mould No. 1 C on both beds (to be correct this should be boned in),

the vertical joint A d being at right angles to the bed. Next work the convex and concave faces through, and also the radiating joint A A′, the block at this stage being a portion of a hollow cylinder similar to sketch (Fig. 7).

Now scribe in the face moulds 1 A on the convex and 1 B on the concave faces (Fig. 4); next work the arch joint a e through (this will have a slight twist); and lastly, for the soffit cut in a draft B e on convex and B′ e' on concave faces, and work the surface through, thus completing the springer.

It may be observed that the soffit is a winding or warped surface, and it will be worked similar to the soffit of winder step, as previously described.

To work the Second Arch Stone, No. 2 A (Fig. 2).



Fig, 5.

For the bed mould 2 C (Fig. 5), project the extreme points a and 4, No. 2 A (Fig. 2) on to springing line; transfer these to the segment line A C on the plan (Fig. 1). This gives from 2 C to 4 and 2 d to 4′, which encloses the bed mould; a a' is the vertical joint and arris of the arch joint a 2, the dotted line 2^a is the horizontal line of the joint on soffit at bottom, and the line b b' is the arris at the top of arch joint, 4 4 a is the bottom arris of the top joint to soffit.

No. 2 A (Fig. 5) is the face mould for the convex face, and No. 2 B (Fig. 5) is the face mould for the concave face; both of these are transferred from 2 A and 2 B (Figs. 2 and 3), with the addition of the square line 4 b, 4 C, and 4 1, 4 2.

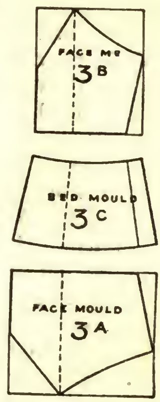


Fig. 6.

Work the top bed first f b, 4 b, and take the bottom bed a 2, 4 C parallel to the top and of the height of the face mould (this is a surface of operation, all being cut away except arris 2 2 a, which must be kept true across the bed). Scribe the bed mould No. 2 C (Fig. 5) on both beds. Now work the two faces convex and concave through, and the radiating joint a a' square with

the top bed, bringing it again into the shape of a portion of hollow cylinder as in sketch (Fig. 7).

Scribe the face mould 2 A on the convex and 2 B (Fig. 5) on concave faces. Work the arch joints *a* 2 and *b* 4, and for the soffit cut in the draft 2 4 on the convex and 2 *a*, 4 *a* on concave faces, and work through as previously described.

The other arch stone 3 A and keystone are worked in a similar manner, the general principles of working being the same.

Note.—The radiating joint lines on the developments (Figs. 2 and 3), to be geometrically correct, should not be straight, being slightly curved. This is apparent on cutting a cylinder by a right line obliquely, the development of which is a compound curve; but in this case the curve is so slight as to be scarcely perceptible, and need not in the present and the following example be taken notice of.

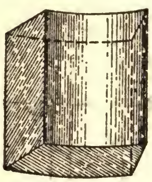


Fig. 7.

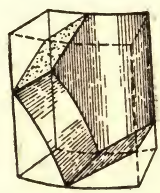


Fig. 8.

To construct a Semi-circular Arch in a Cylindrical Wall, whose line of soffit on the plan is parallel to the axis, the axes of the two cylinders intersecting each other at right angles.

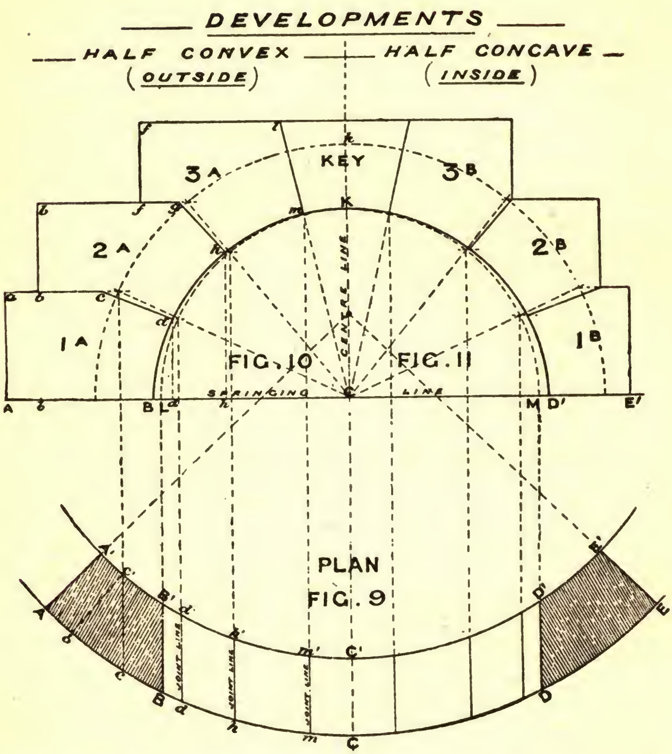
Fig. 9.—Shows the plan of the arch, B C D being the opening. Figs. 10 and 11 are the developed elevations.

In order to prevent confusion with Figs. 9, 10, and 11, and to make matters easier of explanation, three diagrams are here shown, containing Fig. 15, Figs. 16, 17, and Figs. 18, 19, these being slightly exaggerated to show more clearly the working.

Let Fig. 15 be the plan of segment of cylinder, with the semi-cylinder penetrating the same at right angles to the axis at *a e*, *b d*.

Let Fig. 16 be the square section of the quadrant of cylinder, and divide this into any unequal number of equal parts corresponding to the number of arch stones required in Figs. 10 and 11, which in this example is seven, as 1, 2, 3, 4, 5, 6, 7, and pro-

ARCHES *CIRCULAR ON PLAN*



ject on to the segment line *a c b* on plan (Fig. 15), as C 6, 5, 4, 3, 2, 1; transfer this to the springing line *a b*, 1, 2, 3, 4, 5, 6, 7 (Fig. 17), which is now the developed line; erect ordinates, and make them equal in height to the ordinates of the square section, as 1′, 2′, 3′, 4′, etc.; draw line through the intersecting points 1′, 2′, 3′, 4′, etc., giving the curve required on the development at the point of penetration for the outside or convex face of cylinder.

For the development of the inside or concave face, let Fig. 18 be the square section, divided into seven equal parts, projecting the ordinates as before. Transfer from Fig. 15 1^a, 2^a, 3^a, 4^a, 5^a, 6^a, 7^a to the springing line (Fig. 19), erect ordinates and make them equal in height to those of square section at 1, 2, 3, 4, etc., and through the intersecting points 1^a, 2^a, 3^a, 4^a, etc., draw the line giving curve required at the point of penetration for the inside or concave face of cylinder.

For the joints draw radiating lines at 2, 4, 6 (Figs. 16 and 18), and to make them of equal length draw a quadrant line with radius of the square section as *f g h*, project *f g h* on to plan (Fig. 15) as *f g h*, and transfer to the springing line (Figs. 17 and

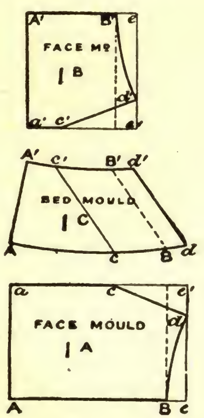


Fig. 12.

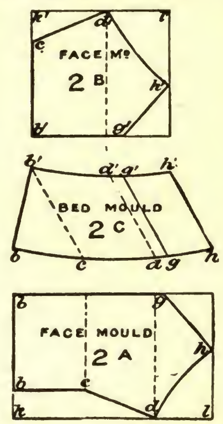


Fig. 13.

19); erect ordinates at *f g h*, making equal in height to those of the square section. Next draw the joint lines *h* 2′, *g* 4′, *f c′* on Fig. 17, and *h* 2^a, *g* 4^a, and *f c′* (Fig. 19); the developed length of joint is thus obtained.

To set up the Elevation on the Developments for the Face Moulds.

Figs 10 and 11.—Let A E′ be the springing line, C K the center line, and L K M dotted line the square section of the cylinder whose center is C. For the development B K D proceed as previously described, and divide into any number of equal parts for the arch stones required—which in this example is seven—and draw the joints; the square holding *a b*, *b f*, *f l* may

be set out at will, but should be set out from the inside or concave face, so as to obtain a parallel arch joint.

The joint $c\,b'$, No. 2 C (Fig. 13), which is the arch joint cutting out to the vertical joint b', illustrates this.

The moulds for working each arch block are a bed mould and two face moulds. These are already set out on plan (Fig. 9) and elevations (Figs. 10 and 11), except the addition of a square line to the extreme size.

To work the springer:

For the bed mould take *A c*, *B d* from the plan (Fig. 9) and transfer to 1 C (Fig. 12); the dotted line B B′ is line of the soffit on the bottom bed, the line $c\,c'$ is the line of joint on top bed, the line $d\,d'$ is the line of arris of the arch joint in soffit, and the line A A′ is the radiating vertical joint. No. 1 A (Fig. 12) is the face mould for convex face, and No. 1 B, Fig. 12, is the face mould for concave face; both of these are transferred from 1 A and 1 B (Figs. 10 and 11), with the addition of the square line $e\,e'$.

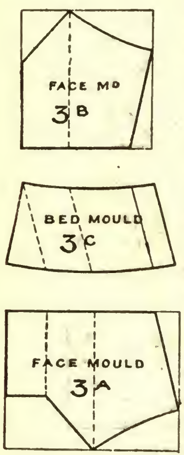


FIG. 14

Work the two beds (bottom and top) parallel to each other, and of the height of the face mould. Scribe the bed mould No. 1 C (Fig. 12), on both beds, and work the two faces convex and concave through, and also the vertical joint A a, which must be at right angles to beds; this will form a portion of a hollow cylinder similar to sketch, Fig. 7. Now scribe in the face moulds 1 A and 1 B (Fig. 12), on the convex and concave faces respectively, and work the arch joint $c\,d$ through, and for the soffit, cut in arrises to the lines, and work drafts parallel to the bed B B′ until the whole of the soffit is finished.

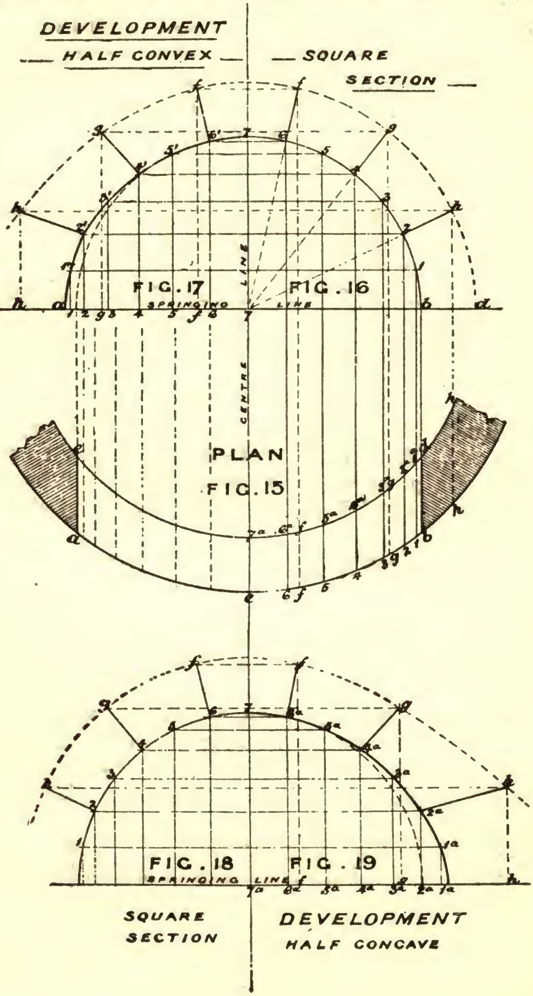
In this arch the soffit is not a winding surface.

To work the Second Arch Stone No 2 A (*Fig.* 10).

Let No. 2 C (Fig. 13) be the bed mould, project the extreme points *b h*, No. 2 A (Fig. 10), on to springing line A C. This being a developed face, it will require folding back on to the segment line A C E of plan (Fig 9), as *b d h*, and transfer this to No. 2 C, which gives the bed mould.

No. 2 A (Fig. 13) is the face mould for convex face, and No.

ARCHES *CIRCULAR ON PLAN*



2 B (Fig. 13) is the face mould for concave face, and both of these are transferred from 2 A and 2 B (Figs. 10 and 11), with the addition of the square line *l*.

Work the two beds (bottom and top) parallel to each other, and to the height of the face mould. The bottom bed is worked as a surface of operation for the application of the bed mould, and it is all cut away except the arris *d d'*. Scribe the bed mould 2 C (Fig. 13) in on each bed, and work the two faces convex and concave through, and scribe in the face moulds 2 A and 2 B (Fig. 13).

Work the vertical joint *b b* square with either the top or bottom beds, and work the bed *b c* and joint *c d;* then joint *g h*, and, lastly, soffit *d h*.

Fig. 14.—Nos. 3 A, 3 B, and 3 C are the face moulds and bed mould of the third arch stone, and together with the keystone are projected and worked in precisely the same manner as the foregoing Nos. 1 and 2 stones.

It will be advisable for the student to work small models, which should be constructed to scale in plaster, clay, or other soft material. The moulds for these models may be cut out of stout drawing paper, and in their application will be found the best method of obtaining knowledge of these subjects.

SKEW ARCH AND NICHES

To construct a Semi-circular Arch Rib, the oblique angle of which does not extend more than ten or twelve degrees from a right angle, the joints being parallel to axis, and in the same planes.

This is not a difficult problem, as the arch within these limits may be set out and worked as a right arch; but beyond these a different principle of construction is necessary.

Fig. 1.—Shows the elevation of the arch, which is a semicircle.

Fig. 2.—Shows the plan of the arch, B G and D J being the opening, B D and G J the inclination or angle of skew, E and F the centers, A and H the outer face line of the arch, and C K the inner face line of the arch.

There is no difference in the outer and inner faces of the arch, both being alike, but the terms are here used for purpose of explanation.

Project A C, B D and G J, H K from the plan to the springing line (Fig. 1), as *a c*, *b d* and *g j*, *h k*, with *e* as center, and *e a* and *e b* as radius, describe the semi-circles *a o h* and *b m g*, for the outside face, and with *f* as center, and the same radius, describe the semi-circles *c p k* and *d n j*, for the inside face. For the joints, divide the arch into any convenient number of equal parts—in this example seven—as *q r s t u v* on line *b m g* of intrados, and with the same divisions repeat on the line *d n j*

SKEW ARCH

ELEVATION

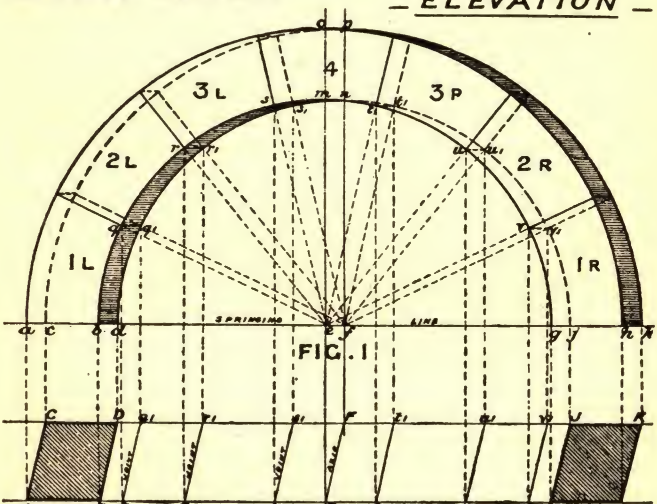


FIG. 2

PLAN

as q' r' s' t' u' v'; from the center *e* draw radiating lines through these points, and produce to the outside curve or extrados for the outside, and for the inside of the arch; repeat the same from the center *f*. It will be observed that the direction of joints is perfectly horizontal, the lines $q\,q'$, $r\,r'$, $s\,s'$, etc., being level; the radiating lines and joints are also parallel to each other, and are therefore in the same place.

This is all the setting out required, with the exception of the joint moulds.

To work the Arch Stones.

Fig. 3.—Let No. 1 L be the face mould of the springer and A and B the joint moulds.

The face mould 1 L is transferred from the elevation Fig. 1, and the bottom bed or joint mould A, from plan (Fig. 2); for the joint mould B, draw a line parallel to joint *e′ f′*, and project *e′ f′* and *g′ h′* as *e f* and *g h*, of an equal and parallel thickness, as X X at A and B.

Work *a′ b′ e′ f′* outside face of springer No. 1 L, to a plane surface, and *c d g h* inside, face parallel to it; scribe the face mould into extreme size on each face as *a′ d′ e′ g′ h′;* scribe in the segment line *f′ b′*, giving arris of soffit on outside face (this may be done by drawing the mould back, as *h′ d′* is the same segment and also the same length as *f′ b′*)

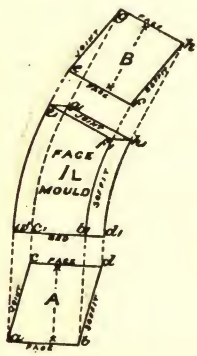


Fig. 3.

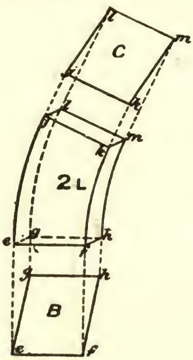


Fig. 4.

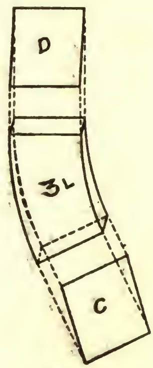


Fig. 5.

Work the bottom bed A, which is horizontal, and square with the vertical face, and scribe in the bed mould as *a b c d*, which will coincide with the lines on the face mould; now work the top joint B; this from the outside face will be full of the square, or, in other words, it makes an obtuse angle with the vertical face. This, however, is given by the face mould, as *e′ f′* is line of joint on the outside, and *g′ h′* on the inside.

Scribe in the joint mould B as *e f g h*, and work the soffit *b′ d′ f′ h′* through, as in a right arch, and finish with the back joint *a′ c′ e′ g′*.

Fig. 4.—No. 2 L is worked similar to No. 1 L; the top joint

mould B of No. 1 is the bottom joint mould of No. 2, and the top joint mould C of No. 2 is the bottom joint mould of No. 3, and so on—this is self-evident. The bevels of these joints are found by projecting the points of the face mould, as *j k l m*, etc., as before described.

Begin by working the two vertical faces *e f j k* and *g h l m* parallel to each other, scribe in the face mould No. 2 to the extreme size, as *e f h j l m*, and work both joints B and C; the top joint C is full of the square, whilst the bottom joint B is slack of the square from the outside face, the amount of the obtuse and acute angle being given on the face mould.

FIG. 5.—No. 3 L and the keystone are worked precisely similar to the foregoing.

One set of moulds for one-half of the arch only is required, as the four face moulds and the four joint moulds will work the complete arch; being a plain arch without mouldings, the stones are reversible; this is apparent on looking at the elevation, but should there be an architrave moulding on one face, a mould to each stone is then required.

To construct a Spherical Niche in a straight wall with horizontal splay beds, and with vertical joints.

FIGS. 6 AND 7.—Show the elevation and plan of the niche.

Let A E be the face line of the niche on plan (Fig. 7), B D the opening and C the center; with C B or C D as radius, and C as center, describe a semi-circle B K D, which is plan of extreme size of inside of niche; project A B C D E to the springing line on elevation (Fig. 6), as *a b c d e*, and at *c* erect perpendicular for the center line. With *c* as center and *c b* or *c d* as radius, describe the semi-circle *b k d* for the outer curve, and divide this into five equal parts as at *f g h i;* from *c* draw radiating lines through these points of division, cutting the horizontal bed at *l m n o*, giving the joints, the bevel of which will be continued horizontally round the niche as at *f i* and *g h*. For joints to the plan draw ordinates at *f g h i* and *l m*, etc., and project them on to line A E on plan (Fig. 7), as F G H I and L M, etc.; at L F M G describe the semi-circles, giving the horizontal line of splay joints. For dividing joints on the plan, take the second course first and divide the line of semi-circle F Q I into four equal parts as P Q R, and from C draw radiating lines through these divisions, producing them on to the line L N O, which gives the joints. The springers 1 L and 1 R in the first course

will require to be about half the depth of others in the same course, in order to break the bond (as will be seen by reference to the plan); therefore, on the line B K D, set off, say, little more than half for the two springers as B S and D V, dividing the remainder into three equal parts as at S T U V, and draw the lines through, radiating from the center to the back, giving the joints in the bottom course.

NICHE — ELEVATION

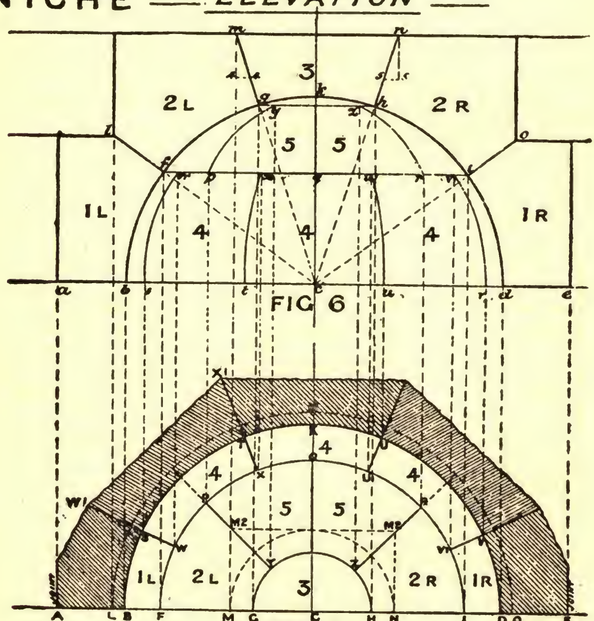


FIG. 7
PLAN

The top course No. 3 is in one stone, and to prevent any tendency to slip out of its place forward, the upper part of bed may be kept square; this would require notching on the inside, as M M 2 and N M 2 on the plan, and *m* 4 4 and *m* 5 5 on the elevation.

The vertical joints are shown on the elevation by projecting up from the plan, as shown by the dotted lines *w p x q*, etc.

To work the Springer.

Fig. 8.—1 A is the bed mould transferred from the plan (Fig. 7), the line A F being the vertical face on the front, F W the horizontal line of arris of soffit and splay joint on the top bed, L O the outside line of splay joint on top bed, the dotted line B S the line of soffit on bottom bed, W W′ the line of vertical radiating joint, and A A′ the line of vertical face joint.

1 L is the face mould transferred from the elevation (Fig. 6), which will also apply as joint mould at W W′.

The form of the stone required to work this will be a wedge-shape prism, containing the bed mould to the extreme size on the top bed as A F W W′; the bottom bed is a little smaller, and is contained within the lines A B S W′, and of the extreme height of the face mould from *a* to *a′*.

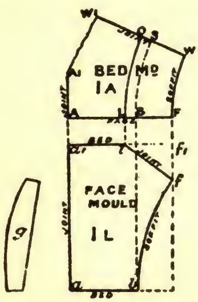


Fig. 8.

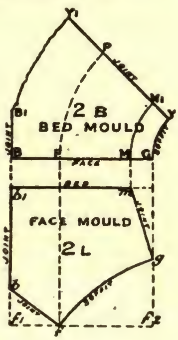


Fig. 9.

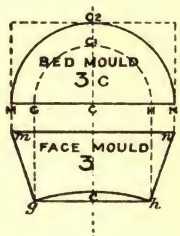


Fig. 10.

Begin by working the front vertical face A B F, and scribe the face mould 1 L on, as *a b f l a′*. Work the vertical joint A A′ as *a a′* square with the front face, and bottom and top beds square with the front face, scribing on the bed mould 1 A, and also the inside vertical joint W W′, scribing in the face mould as *a b f l a′*. It is necessary to work the whole of the top bed, although a portion from *l* to *f* 1 will be cut away for the splay joint, in order to get horizontal line F W at *f;* to obtain this arris, square down the concave line from F to W to the depth at *f*, or a draft from F to W may be worked by the aid of a template. This being done, trammel the line *f* parallel to *f* 1, giving the arris line required; the line L O is marked on the

top bed with the template, and the splay joint from f to l then worked off. The soffit now remains to be worked; cut in the drafts B S on the bottom bed and F W on the top bed, and drafts b f on the face and joint; a convex template is used as at g for the intermediate drafts, which are cut in as close as convenient, until the whole surface is worked.

The template g must not be applied parallel to the joints, but to lines radiating from the center.

The three No. 4 stones will be worked similarly to the foregoing; one vertical joint is worked first as a surface of operation, instead of the front face as in the springer.

To work No. 2 L Stone.

FIG. 9.—2 B is the bed mould transferred from the plan (Fig. 7), the line B G being the vertical face on the front, and G Y the horizontal line of the arris of soffit and the splay joint on the top bed, M M′ the outside line of the splay joint top bed, the dotted line F P the line of soffit on bottom bed, Y Y′ the line of vertical radiating joint, and B B′ the line of vertical face joint.

2 L is the face mould, transferred from the elevation (Fig. 6), which will also apply as joint mould at Y Y′.

The form of stone required to work this will be a wedge-shape prism, containing the bed mould, to the extreme size as B G Y Y 1, and of the extreme height of the face mould, from f 1 to b 1.

Begin by working the front vertical face, and scribe the face mould 2 L on as b 1 b f g m. Work the vertical joint b b' square with the front face, also the top bed, and scribe the bed mould on. Work the bottom bed as a surface of operation; the only part required being the arris of the splay joint, and soffit F P, the rest of the bed being cut away.

This is the easiest and most accurate way of working, but the bed need not necessarily be worked as a whole, a portion only being required, sufficient to obtain the arris line F P; in this case the soffit F G should be worked after the arris line is drawn on the bed, by a convex template made from f to g, and the splay joint is worked from a beveled template made from g f b.

The remaining portion of the stone is worked as before described to springer.

The two No. 5 stones are worked similarly.

To work the Keystone No. 3.

Fig. 10.—3 C is the bed mould transferred from the plan (Fig. 7), the line M N being the vertical face on the front, M C 2 N the top line of the splay joint, and G C 1 H the line of arris of soffit, and the splay joint on bottom.

No. 3 is the face mould transferred from the elevation (Fig. 6),

NICHE — ELEVATION —

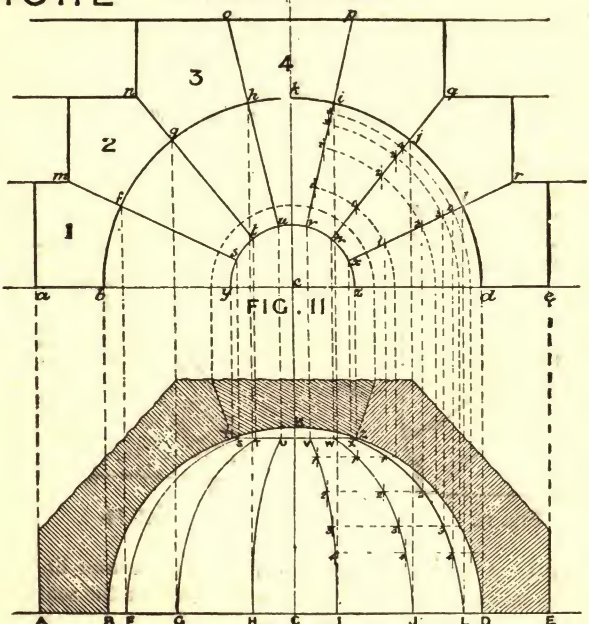


FIG. 12.
— PLAN —

Begin by working the vertical face M N, scribing in the face mould as *g h m n*. Work the top bed through square with the face, scribing in the bed mould, also the bottom bed parallel to the top at extreme points *g* and *h*, and with a template scribe G C H the arris of the soffit and the splay joint. Work the joint round tc the splay lines, then the soffit by cutting in the draft *g c h* on the front, and with a convex template made from C to C1, complete the surface.

The niche need not be jointed as here shown, for much depends on its size, and the size of the stone convenient to use, but the general principle of working will be the same.

To construct a Spherical Niche in a straight wall, with joints radiating from the center.

FIGS. 11 AND 12.—Show elevation and plan of the niche.

Let A E be the vertical face line of the niche on the plan (Fig. 12), B D the opening, and C the center. With C B or C D as a radius, and C as a center, describe the semi-circle B K D, which is the plan of extreme size of the inside of niche, and project A B C D E to the springing line *a e* on the elevation (Fig. 11),

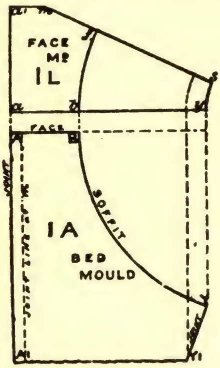


Fig. 13.

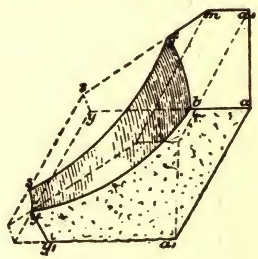


Fig. 14.

as *a b c d e*. At *c* erect a perpendicular for the center line, and, with *c* as center and *c b* or *c d* as radius, describe the semi-circle *b k d* for the outer curve. With *c y* as a radius and *c* as the center, describe a semi-circle for the center stone, which may be of any convenient size. Divide the semi-circle *b k d* into seven equal parts as *f g h i j l*, and through these points of division from *c* draw radiating lines cutting horizontal beds at *m n o p*, etc., and the center stone at *s t u v*, etc., which gives the joints. Draw ordinates from *f g h i*, etc., and project on to the line A B as F G H I, etc., and repeat the same at *s t u v*, etc., on the line Y Z, giving joint lines on the plan; to determine points in the curve of the soffit for templates, the dotted lines at the right hand of the niche show how they

are obtained. The dotted segment line from 1 to 1, 2 to 2, 3 to 3, etc., on elevation will be the section of curve at corresponding points on the plan at 1 1, 2 2, 3 3, etc., and also gives the points in the line of curve for the joints on plan, although the last named is not necessary for the setting out or the working.

To work the Springer 1 *L.*

Fig. 13.—1 A is the bed or joint mould transferred from the plan (Fig. 12), the line A B being the front vertical face, B Y the line of soffit, Y Y 1 the splay joint, and A A 1 the vertical face joint.

No. 1 L is the face mould transferred from the elevation (Fig. 11).

The form of stone required will be that of a wedge-shape prism (as in sketch, Fig. 14), containing the face mould to the extreme size as *a′ a y s m.*

Begin by working the bed or joint *a b y*, keeping the segmental line B Y fair for arris, and scribe the bed mould 1 A on. Work the vertical face and scribe in the face mould 1 L, and the other bed *m f s*, scribing in the bed mould 1 A. Work the vertical joint *a a′*, and top bed *a′ m*, and, lastly, the soffit, the working of this being guided by one or two templates made from 1 1, 2 2, etc.

The remaining stones are worked similar to the foregoing, keeping in mind the principle that the stone is contained within the wedge-shape prism, thus making it easy of comprehension.

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BRICKLAYERS' GUIDE

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STONEMASONS' GUIDE

NOTICE

To the many workmen who are purchasing the publications under the authorship of Fred T. Hodgson, and who we feel sure have been benefited by his excellent treatises on many Carpentry and Building subjects, we desire to inform them that the following list of books have been published since 1903, thereby making them strictly up-to-date in every detail. All of the newer books bearing the imprint of Frederick J. Drake & Co. are modern in every respect and of a purely self-educational character, expressly issued for Home Study.

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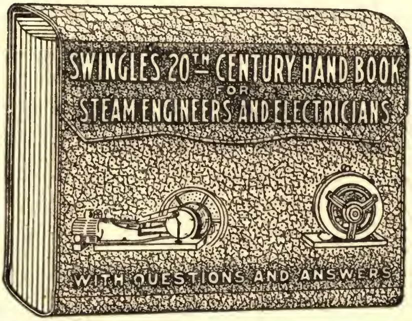

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